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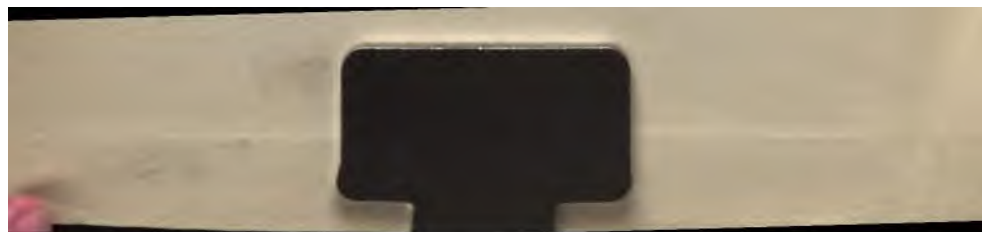
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METROPOLITAN WATER BOARD

THIRD ANNUAL REPORT



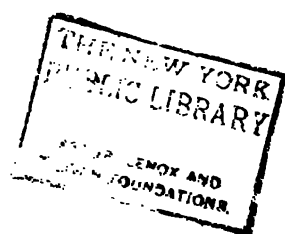
JANUARY 1, 1897



Mass.

Michael Miles Bl
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WACHUSETT AQUEDUCT — ASSABET BRIDGE.

THIRD ANNUAL REPORT

OF THE

METROPOLITAN WATER BOARD.

COMPLIMENTS OF

Metropolitan Water Board,

3 MT. VERNON STREET,

to Dr. J. S. Billings.

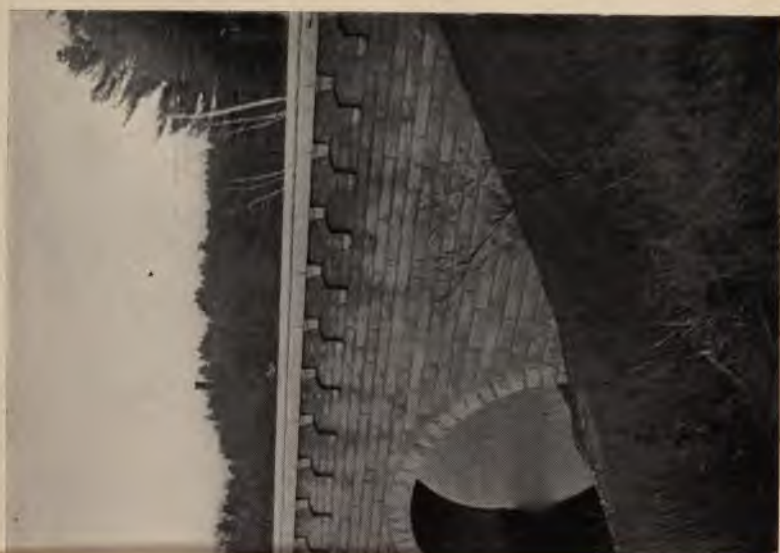
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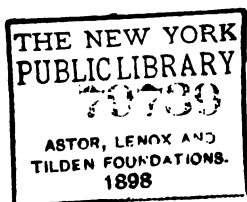
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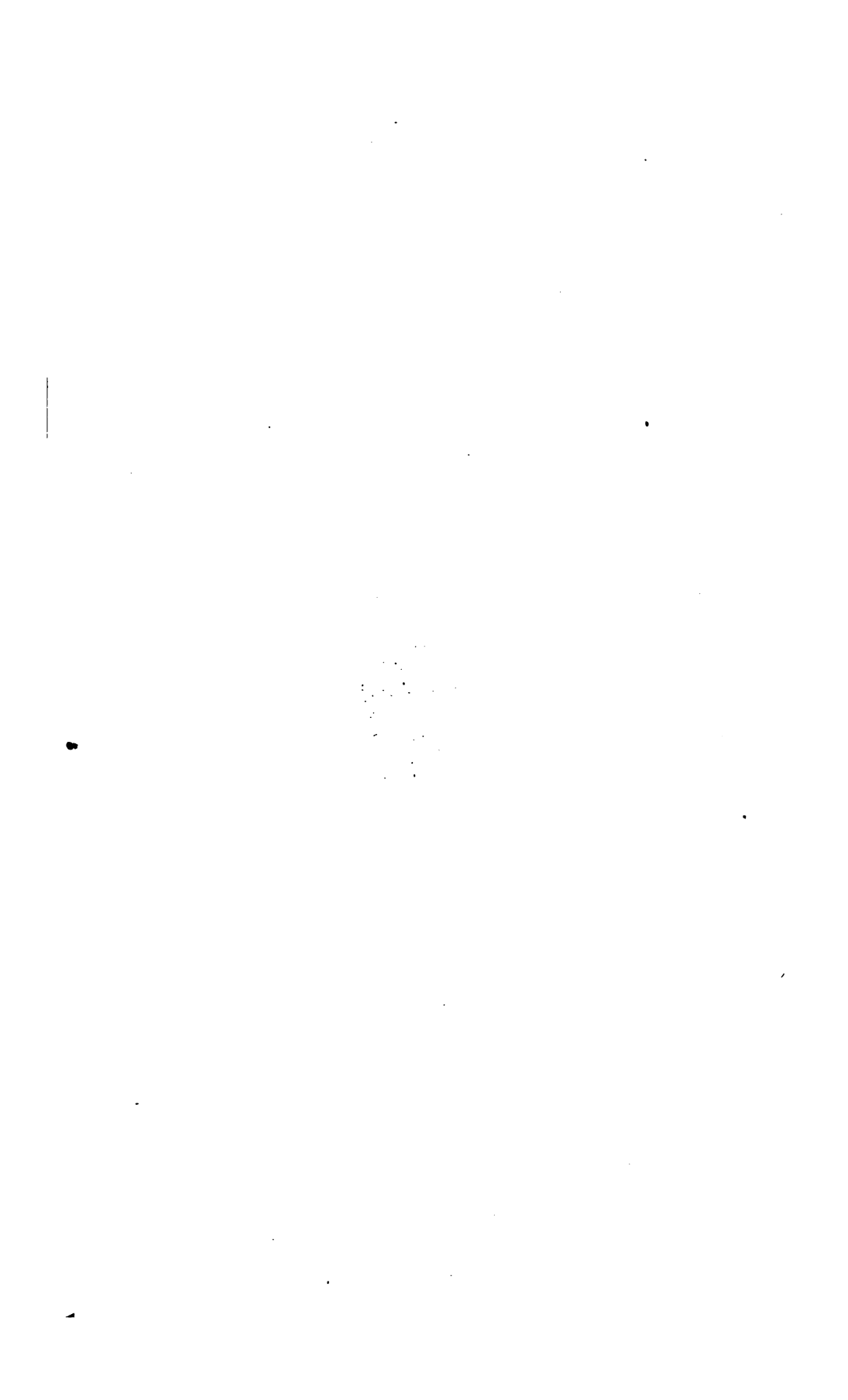
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Mass.
Milton B.
1884



The taking of the lands, reservoirs, aqueducts, pipe lines and other water works of the city of Boston, westward of the Chestnut Hill Reservoir, and other minor takings, has involved a great deal of additional labor.

Papers have been prepared for the settlement of 121 cases during the year. Many of these settlements involved the titles of two or more parcels, one of them as many as eleven separate parcels of land. Many of the titles were found defective, and required the obtaining of releases, and, in some cases, the conduct of proceedings in the probate and other courts for the necessary authority to perfect the title.

There were twelve takings of lands and easements under the right of eminent domain given to the Board under the statutes of 1895, in addition to the takings, on Jan. 1, 1898, of the water works of the city of Boston and of Spot Pond and the lands immediately surrounding the pond.

In order to prepare for the takings to be made from the city of Boston, it was necessary to examine all the takings which had been made by the cities of Boston and Charlestown for the purposes of water supply from the year 1846 to the present time, and also all the deeds to and from the cities of Boston and Charlestown in the counties of Middlesex, Norfolk and Worcester. These deeds have been copied for preservation, necessary plans have been made and compiled, and the various parcels have been properly plotted upon the plans.

The work required for the taking of the Spot Pond lands was similar, but much less in amount.

The preliminary examination of titles of the land to be taken for the Wachusett Reservoir and Aqueduct have now been substantially completed in the registries, but considerable additional work is required in most cases when a settlement is reached and the title is perfected for the purpose of a release by the owners.

Beside the foregoing examinations, considerable work has to be done from time to time in other portions of the Metropolitan District, as rights and easements are required in connection with the laying of pipe lines and other local work.

The examination of titles, the various investigations, the copying required and the preparation of the various papers have called for the additional employment, for more or less time, of the following-named

examiners: Walter M. Lindsay, Samuel H. Longley, Herbert S. Riley, James A. Saxe, Frank E. Bradish, Walter Soren, Miss Alline E. Marcy and Miss Celia M. Tibbetts. Three stenographers and typewriters have been regularly employed, and, in addition, three others have been employed temporarily.

(4) *Police.*

In accordance with the requirement of chapter 488 of the Acts of the year 1895, that the Board should furnish, without charge, to the towns within which any work is done under the authority of the act, such additional police protection as might be necessary in consequence of such work, the Board has provided for the maintenance of police officers about the Sudbury Reservoir, along the line of the Wachusett Aqueduct and at the proposed Wachusett Dam and Reservoir, as follows:—

Sudbury Reservoir.

Southborough,	. . . . .	15 officers.
Marlborough,	. . . . .	9 "

Wachusett Aqueduct and Reservoir.

Clinton,	. . . . .	5 officers.
Berlin, .	. . . . .	8 "
Northborough,	. . . . .	7 "
Boylston and West Boylston,	. . . . .	2 "
Total number,	. . . . .	46 "

The officers in Southborough were appointed, as required by the agreement formerly made by the city of Boston with the selectmen of the town of Southborough, by the selectmen, and the officers in the city of Marlborough were appointed by the mayor of that city, subject to the confirmation of the Board, and were under the supervision of the chief of police of Marlborough. The officers in the towns of Clinton, Berlin and Northborough were appointed by the selectmen of the respective towns, with the consent of the Board, those at Clinton being under the control of the chief of police of that town, and those in the towns of Berlin and Northborough being under the direction of Isaac M. Drew, appointed by the Board. Frank H. Baldwin, who is also a deputy sheriff for the county of Worcester, was designated by the Board to act as its

officer in the towns of Boylston and West Boylston, and he has also a general oversight and care of the property of the Board in these towns.

Headquarters for the police for the district of the Wachusett Aqueduct have been maintained at South Berlin. Police headquarters for the region of the Sudbury Reservoir have been continued at Fayville in Southborough, in a building belonging to the Commonwealth. One of the buildings on Clarendon Street in West Boylston, which had been purchased by the Board, was set apart as a police station for Boylston and West Boylston, and has been equipped for the purpose, and an officer has been put in charge there as assistant to Mr. Baldwin.

The Board expressed to the town of Clinton a willingness to make a payment of the sum of \$1,500 toward defraying the expenses of improved police quarters in that town, with the understanding that this amount should be the share of the Commonwealth. This appropriation, however, has not yet been accepted by the town.

(5) *Offices and Buildings.*

The office of the Board and of the administration department has been maintained at No. 3 Mt. Vernon Street in Boston, and the remainder of this large building has been devoted to the uses of the conveyancing and the engineering departments. The six stories of this building, however, have been inadequate for all these purposes, and application has been made to the Governor and Council for the use of the upper stories of the adjoining building, No. 2 Mt. Vernon Street. The proximity of these buildings to the State House, their convenient situation for the many visitors who come from the towns so directly interested in the various operations of the Board, the opportunity afforded by the building for light both in front and in rear, and the large amount of floor room to be obtained, have rendered them especially adapted to the work of the Board, and quarters of equal capacity and of like conditions could not be obtained except by a large expenditure.

A room in Worcester at convenient access to the Registry of Deeds has been in use for the title examiner in Worcester County and his assistants.

The office building, which was in process of erection a year ago in Clinton, has been completed, and affords excellent facilities for

the engineering forces which are required in the vicinity of the Wachusett Dam and Reservoir. The building is spacious, is itself sufficiently fire-proof, in connection with a large brick and iron vault, to secure the safety of the plans and other papers, and is reasonably easy of access to the sections where the work is to be carried on. The building cost for its erection \$9,866.87, and the additional sum of \$3,609 was paid for the land. It will be required for the purposes of the Board for many years, at least, to come, and perhaps may permanently remain as the headquarters of engineering operations in this section.

Branch offices for the engineering department have been maintained in West Boylston, Northborough and Southborough.

Pipe yards for receiving and storing the pipes received from the various foundries have continued to be maintained, one at Edgeworth in Malden, on the line of the Boston & Maine Railroad, one at Park Street in Somerville, and another at the end of Windsor Street on the boundary between Somerville and Cambridge, on the line of the Fitchburg Railroad. A pipe yard for the southern section was established in Brighton on the line of the Boston & Albany Railroad, near the Brighton station, and another on the line of the Providence branch of the New York, New Haven & Hartford Railroad, a short distance from the Forest Hills station. The Somerville pipe yard at the end of Windsor Street was, however, discontinued at the end of the year.

(6) *Names of Dams, Reservoirs and Aqueducts.*

The Board, in anticipation of the takings to be made of the works of the city of Boston, deemed it advisable to change in some respects the designations which had been applied to the various dams, reservoirs and aqueducts, not only of those built by the city of Boston, but of those in process of construction by the Board. They have accordingly adopted the following nomenclature, which is to apply in the future:—

Wachusett Dam.—The proposed dam to be erected at Clinton on the South Branch of the Nashua River.

Wachusett Reservoir.—The proposed reservoir to be built upon the South Branch of the Nashua River, extending from the dam at Clinton, through Boylston and West Boylston, and into Sterling, hitherto called the Nashua Reservoir.

Wachusett Aqueduct. — The aqueduct hitherto called the Nashua Aqueduct, including the tunnel, covered aqueduct and open channel, extending from the dam at Clinton to the new Sudbury Reservoir in Southborough and Marlborough.

Sudbury Reservoir. — The reservoir begun by the city of Boston and just completed by the Board in Southborough and Marlborough, hitherto known as Reservoir No. 5.

Sudbury Dam. — The dam in Southborough, hitherto known as Dam No. 5.

Framingham Dam No. 1. — The dam in Framingham in the Boston Sudbury system, hitherto known as Dam No. 1.

Framingham Reservoir No. 1. — The reservoir in the Boston Sudbury system in Framingham, hitherto known as Basin No. 1.

Framingham Dam No. 2. — The dam in Framingham, hitherto known as Dam No. 2.

Framingham Reservoir No. 2. — The reservoir in Framingham and Ashland, hitherto known as Basin No. 2.

Framingham Dam No. 3. — The dam in Framingham, hitherto known as Dam No. 3.

Framingham Reservoir No. 3. — The reservoir in Framingham hitherto known as Basin No. 3.

Ashland Dam. — The dam in Ashland in the Boston-Sudbury system, hitherto known as Dam No. 4.

Ashland Reservoir. — The reservoir in Ashland, hitherto known as Basin No. 4.

Hopkinton Dam. — The dam in the Boston-Sudbury system in Ashland, near Hopkinton, hitherto known as Dam No. 6.

Hopkinton Reservoir. — The reservoir in Hopkinton and Ashland, hitherto known as Basin No. 6.

Whitehall Dam. — The dam at the Whitehall Pond in Hopkinton.

Whitehall Reservoir. — The reservoir in Hopkinton, hitherto known as Whitehall Pond.

The Cochituate Lake, the Cochituate Aqueduct, the Sudbury Aqueduct, the Chestnut Hill Reservoir and Spot Pond will hereafter continue to be designated by the names by which they have previously been called.

II. DUTIES IMPOSED UPON THE BOARD.

The Metropolitan Water Act, chapter 488 of the Acts of the year 1895, made it the duty of the Board to construct, maintain and operate a system of water works, in accordance with plans and recommendations submitted by the State Board of Health in that year; and the Board was required to provide a sufficient supply of pure water for the cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop. The Act further requires that other cities and towns, any part of which are within ten miles of the State House, shall be admitted into the Metropolitan Water District on such payment of money as the Board shall determine, and also provides for supplying water to water companies owning pipes and water systems in towns within said ten miles, and for permitting the Board to furnish water to still other cities and towns and water companies.

The Legislature authorized the issue of bonds to the extent of \$27,000,000, the proceeds to be applied to carrying out the purposes of the Act.

The great features of the scheme were the construction of a dam and storage reservoir upon the South Branch of the Nashua River, the taking the waters of that river and diverting them into the Sudbury system of the city of Boston, and the making the waters of the South Branch of the Nashua River, in connection with the waters of the Cochituate and Sudbury systems, belonging to the city of Boston, available for the whole Metropolitan District as their future water supply.

III. WORK OF CONSTRUCTION.

(1) *Wachusett Dam and Reservoir.*

Little has been done toward the actual construction of the Wachusett Dam and Reservoir, formerly referred to as the Nashua Dam and Reservoir. The engineering department has, however, been constantly employed in the necessary investigations preliminary to the adoption of plans and in the making of plans and surveys.

Sufficient borings of the river have been made so that the actual

site of the proposed dam has been fixed. Many borings have been made and test pits dug for fixing definitely the location of the north and south dikes, and various investigations made of the nature of the gravel and sand and of the permeability of the soil. It is expected that the plans will be completed and a portion of the contracts be made for the construction of the north dike and of the large dam during the coming year.

Surveys have been continued and nearly completed of the area which is to be submerged, and of a large extent of territory which will form the margin of the proposed reservoir. The entire area to be submerged has been plotted for the purpose of laying out sections preliminary to the letting of the contracts for the removal of the soil, and estimates have been made of the amount of soil which must be excavated. Something more than a square mile of the area has also been cleared by the removal of wood and timber and the burning of the brush.

Considerable progress has been made in the construction of the new road which is to take the place of the River Road, so called, between Clinton and Boylston. A portion of the road in Boylston, considerably more than a mile long, has been completed, and plans have been made for the building of the road from the Lancaster Mills in Clinton to connect with the completed portion in Boylston.

A temporary dam has been constructed in Clinton, just above the site of the great dam to be built, which is not only a necessary preliminary to the construction of the great dam, but is also sufficient to enable the diversion of the water of the river into the Wachusett Aqueduct.

In order to construct the temporary dam and to make the connection with the aqueduct, it was necessary to tear down the dam of the Lancaster Mills, and to supply the corporation with the water which the Act required to be furnished them after the diversion of the river; and accordingly a main pipe was laid from the temporary dam to the main building of the corporation.

No taking of the waters of the river was made during the year, and the only taking of land was of a small area of $28\frac{1}{2}$ acres, much of which were at the bottom of the Lancaster Mill Pond, and laid bare by the construction of the dam. The draining of the pond furnished the necessary opportunity for the removal of the soil

from the bottom of the pond, and the work of stripping the soil from the bottom of the great reservoir has been so far begun.

The continued examinations made for the purpose of fixing the location of the north dike have shown that it is a necessity to take the whole of the Catholic cemetery in Clinton. At an early period it had been hoped that this necessity might be avoided, or that at least a very small portion of the cemetery only would be required. Further investigations, however, proved that a considerable portion would be submerged, and the remainder of the cemetery would be so near the water line that all considerations required the removal of the entire cemetery; and the Board was reluctantly compelled to decide upon its removal. The work of removing a large number of bodies is a difficult one, but every means will be taken to effect the removal without disagreeable results, and with proper consideration for the remains of the deceased and the feelings of the relatives and friends.

The following is a summary of the expenditures on account of the Wachusett Dam and Reservoir:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Contracts for construction,	\$25,893 19	\$25,893 19
Real estate:—		
Mill property and water rights,	246,000 00	1,011,000 00
Other property for reservoir and margins,	361,586 75	459,750 75
Engineering,	57,117 44	104,744 72
Preliminary and additional work and other ex- penses,	114,858 56	161,668 30
	\$805,455 94	\$1,766,056 96

(2) *Wachusett Aqueduct.*

The Wachusett Aqueduct, which has been hitherto called the Nashua Aqueduct, was begun early in the year 1896. The work first begun was the construction of the 2 miles of tunnel in Clinton and Berlin, then followed the building of the covered masonry conduit extending 7 miles farther, through Berlin, Northborough



WACHUSETT AQUEDUCT — SECTION OF TUNNEL AT JUNCTION OF ROCK WITH BRICK LINING.



and Marlborough, and finally the construction of the open channel, which extended the last 3 miles to the reservoir in Southborough.

The contract for the construction of the 2 miles of tunnel was very satisfactorily completed in November, 1897. The tunnel is made capable of conveying 300,000,000 gallons of water daily. It is built entirely through rock, and for about one-half of the distance the rock was found to be so compact as not to require a lining. The lining, where required, is faced with brick. The grade of the tunnel is 1 foot in 5,000 feet.

The contract for the 7 miles of the covered masonry conduit, except for the bridge over the Assabet River, though let in several sections, was undertaken entirely by a single contractor. The carrying out of the contract was found to involve in several sections considerably more difficulty than was anticipated at the outset, but the entire contract was successfully completed before the close of the year 1897. The grade of the conduit is 1 foot in 2,500 feet.

The construction of the bridge over the Assabet River, 359 feet in length, was made a separate contract, and was undertaken, and was successfully accomplished on Sept. 1, 1897, considerably before the time allowed for its completion.

The construction of the 3 miles of open channel was last begun, and the work also encountered unexpected difficulties, so that it was not, as anticipated, absolutely completed by the end of the year 1897, but had, however, so nearly reached completion that no doubt is felt that it will be ready to receive the water, when required, from the Nashua River.

The following table shows the expenditures on account of the Wachusett Aqueduct:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Contracts for construction,	\$1,089,356 05	\$1,293,878 66
Real estate settlements,	19,585 00	31,922 50
Engineering,	78,912 70	139,902 88
Preliminary and additional work and other ex- penses,	36,607 89	57,452 07
	\$1,224,461 64	\$1,523,156 11

It is estimated that the sum of \$13,450 will be required for the completion of the open channel. Some additional work will be required in the way of levelling, loaming and grassing portions of the aqueduct, and a small amount will be required for the settlement of additional land damages.

The settlements for land damages have been effected in 29 cases, and the number unsettled is 44.

In some cases it has been found that the construction of the aqueduct in lower lands has caused a temporary failure of the water supply of adjoining estates, and in other cases there seems to have been a permanent failure of the water supply. In most of the latter cases the Board has given new supplies by the construction of a well and laying of a line of water pipe.

(3) *Sudbury Dam and Reservoir.*

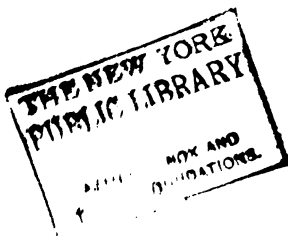
The only portions of the Sudbury Reservoir (hitherto known as Reservoir No. 5), about which there has been a delay in the completion, have been the section near Sawin's Dam and the northerly section in the city of Marlborough. The work upon the former section had been undertaken by the city of Boston before the organization of the Metropolitan Water Board, but the city had been compelled to suspend its work, and failed to make an early completion of this portion of the reservoir, by reason of injunction proceedings which were begun by the trustees of the estate of Joseph Burnett, deceased, and which were not dissolved until the month of October in the year 1897. Since the injunction was dissolved this portion of the work has been prosecuted with great speed, and will be completed in time for the introduction of the water from the Nashua River.

Great difficulty was found in the Marlborough section of the reservoir, on account of the depth of mud which had to be removed. The work was far advanced towards completion in December, when it was necessary to suspend operations on account of the cold weather. It will be resumed late in the coming summer, when the water of the reservoir shall be drawn down. The reservoir, however, is so substantially completed, that it will be ready to receive the water when diverted from the Nashua River.

The city of Boston had expended, at the time that the work was undertaken by the Metropolitan Water Board, in construction of



WACHUSETT AQUEDUCT — GENERAL SECTION OF COVERED AQUEDUCT.



the dam and reservoir, a considerable sum, which has been reimbursed to the city, in accordance with the requirements of the Metropolitan Water Act that the Commonwealth should reimburse the city of Boston for all moneys paid by the city for land damages, or otherwise, in connection with the building of this reservoir, and the protection of the purity of its waters. The expenditures made by the city in the taking and purchase of lands and in the construction of the dam and reservoir have all been audited and agreed to, and the entire amount has been paid to the city in reimbursement.

The Sudbury Reservoir, when completed, will, until the completion of the Wachusett Reservoir, be by far the largest storage reservoir in New England, will have an area of about 2 square miles, an average depth of 19 feet, and will have a storage capacity of about 7,500,000,000 gallons.

The following is a summary of the expenditures made on account of the Sudbury Dam and Reservoir:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Reimbursement to city of Boston, for payments made on this work,	\$554,766 84	\$1,154,766 84
Contracts for construction,	656,002 80	1,339,897 54
Land settlements,	40,395 00	40,395 00
Engineering,	46,512 44	86,220 38
Preliminary and additional work and other ex- penses.	32,287 14	55,709 66
	\$1,329,964 22	\$2,676,989 42

It is estimated that the sum of \$175,000 will be required for the absolute completion of the reservoir.

(4) *Connection with the Sudbury Aqueduct.*

But little work has been required to connect the Sudbury Reservoir with the Sudbury Aqueduct. The water is conveyed from the dam by the open waterway to the Framingham Reservoir No. 3. A 48-inch main pipe has been laid a length of a little more than a

mile from Framingham Reservoir No. 3 to Framingham Dam No. 1. This pipe is additional to a similar pipe laid many years ago, and through both pipes the water of the South Branch of the Nashua River, as well as the water of this portion of the Sudbury watershed, will flow into the Sudbury Aqueduct and through this aqueduct to the Chestnut Hill Reservoir.

Some further work will have to be done during the coming year, in order efficiently to convey the increased amount of water through the Sudbury Aqueduct.

(5) *Chestnut Hill Pumping Station.*

Work was begun in September last for the construction of an addition to the present Chestnut Hill pumping station, and has rapidly progressed toward completion. This addition will contain a new pumping engine for the high service, having a daily capacity of 30,000,000 gallons, which is now in process of building. It is expected that the addition to the building will be completed and that the pumping engine will be put into service during the coming year. The capacities for high-service pumping will thus be greatly enlarged.

Considerable progress has been made toward the preparation of plans for a low-service pumping station, to be erected on the lands hitherto belonging to the city of Boston, near the Chestnut Hill Reservoir, and a little easterly from the present pumping station. Three engines, each having a capacity to pump 35,000,000 gallons daily, have been contracted for, to be placed in the new station when it is completed.

When all these additions are made, the maximum daily capacity of the engines at Chestnut Hill will be 70,000,000 gallons for the high service and 105,000,000 gallons for the low service.

(6) *The Main Distributing Pipe Lines.*

The work of laying main distributing pipe lines through the different portions of the Metropolitan Water District has been vigorously prosecuted during the whole of the season.

One entire main line of 48-inch pipe has been completed from the Chestnut Hill Reservoir to Spot Pond, and the larger part of a second line has been laid. Main lines have also been completed from Spot Pond through Malden, Everett, Chelsea and Revere.

A main line has been begun and about half completed, running from Chestnut Hill Reservoir southerly through West Roxbury, Dorchester and Milton to Quincy.

During the year 27.7 miles of pipes have been laid, making, with the pipes laid in the preceding year, a total length of main pipes of 42.75 miles. Of these 20.71 miles are 48-inch pipes. About 10 miles of pipes are to be laid in order to make a proper connection with all of the cities and towns now included in the Metropolitan Water District. This work will be continued and substantially completed during the coming year.

The total number of tons of pipes used to this time is about 57,000, of which about 37,000 tons were laid in the year 1897; besides, many valves of various sizes and various castings for gates and chambers have been required.

The following is a summary of the expenditures on account of the Distribution Department:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Contracts for construction,	\$1,026,584 38	\$1,537,550 64
Land settlements,	18,100 00	20,586 50
Engineering,	78,513 49	142,678 53
Preliminary and additional work and other ex- penses,	60,163 85	87,049 91
	\$1,183,361 22	\$1,787,865 58

The work had so far progressed at the end of the year that water could be supplied on Jan. 1, 1898, from the Metropolitan System, not only to the Boston district, including East Boston and Charlestown, but also to the cities of Chelsea, Everett, Somerville, Malden and Medford, and to the town of Melrose. In some places, however, the high-service connections have not been made, so that pumping is still required in several of the cities. Arrangements have been completed so that in the near future water can be supplied to Revere and Winthrop, and during the coming season to the towns of Watertown and Belmont, and also to the city of

Quincy. The city of Newton and the town of Hyde Park have not yet notified the Board that they have so reached the capacity of their present sources as to require a supply from the Metropolitan Water Works.

(7) *Spot Pond and Middlesex Fells Reservoir.*

Some work has been done upon Spot Pond preliminary to the taking of the pond and the adjoining shores for the purpose of a northern low-service reservoir. A gate chamber and inlet have been constructed, and connection has been made with the 48-inch pipe main leading from the Chestnut Hill Reservoir. The pond will be used during the coming year for the purpose of a reservoir; but it is not intended, at present, to proceed with the work which will be eventually required for the removal of the loam and mud from the bottom of the pond, and perhaps for raising somewhat the level of the water. It is expected, however, that a new pumping station will be built during the coming season upon the easterly shore of the pond.

A site for a high-service distributing reservoir in Middlesex Fells, about one mile south-easterly from the Melrose pumping station at Spot Pond, has been selected, and has been cleared of wood and shrubbery, and plans are in a considerable state of advancement for the preparation and construction of the reservoir. It is expected that this reservoir will have a capacity of 38,000,000 gallons, and its surface will be 271 feet above the Boston city base, which will give it a height of 117 feet above Spot Pond and 137 feet above the Chestnut Hill Reservoir.

(8) *Takings and Purchases of Land.*

Twelve different takings of land, under the right of eminent domain given to the Board, have been made during the year 1897. These takings embraced land on Forbes Hill in the city of Quincy, for the construction of a reservoir and stand-pipe; lands in Boston, Malden and Chelsea, for pipe laying; lands in Boylston and Berlin, for the construction of highways; a small parcel included within the limits of the Lancaster Mills Pond; land in Marlborough, to be used in connection with the Sudbury Reservoir; and an additional right to fill lands in Southborough belonging to the Burnett estate.

These takings are in addition to the eight takings of a similar

character made in the year 1896. They embrace comparatively, however, but a very small amount of land, not more than 148 acres, and in 7 acres easements only were taken. The Board has acquired by deed, through voluntary settlements with the owners, a very large proportion of the area to be taken for the construction of the Wachusett Reservoir. These purchases have been made in Boylston, West Boylston, Clinton and Sterling, and embrace more than 3,300 acres, and include considerably more than two-thirds of the entire area which is to be acquired. Among the purchases made in the year 1897 are included the Congregational and Baptist churches in West Boylston, and the Sawyer Mills in Boylston, besides many farms, dwelling-houses and business establishments. A settlement has been effected with the Lancaster Mills, not only for its property taken within the location of the reservoir, but also for the incidental damages occasioned by the building of temporary works and by the diversion of the water of the river from its mills.

The amount paid for lands, buildings and water rights in connection with the reservoir, for the thirteen months ending Dec. 31, 1897, has been \$607,586.75, and the additional amount of \$611,850.00 has been paid on account of the damages for the diversion of the water of the South Branch of the Nashua River.

The Board has deemed it wise to exercise as little as possible its power under the statute of arbitrarily taking lands and other valuable rights, and divesting the people of their ownership, and has pursued the policy of acquiring the necessary lands and rights by mutual agreement with the owners, and of permitting the owners to occupy their lands, so far as consistent with the operations of the Board, until they should be required. The Board has at the same time stood ready to meet any of the owners who have desired to part with their property and to make settlement. The few takings which have been made have, with two or three exceptions, been takings made with the assent of the owners and chiefly for the perfecting of titles.

The Metropolitan Water Act, however, required the Board to take, on or before the first day of January, 1898, in behalf of the Commonwealth, all the lands, reservoirs, aqueducts, pipes, pumping stations and other property held by the city of Boston for water supply and storage, westward of the Chestnut Hill Reservoir,

including the Mystic Reservoir and Works, and also to take Spot Pond, with the lands immediately surrounding the pond belonging to the cities of Malden and Medford and the town of Melrose. The Act further required the Board to begin the operation of these works and to supply water as far as possible to the city of Boston, and to the other cities and towns in the Metropolitan Water District. These takings were accordingly made on January 1, and the Board undertook to supply the city of Boston, and, as far as the construction of its works would allow, the several other cities and towns in the District with water, as required by the Act, by delivering the same into main water pipes or into reservoirs in the city or town.

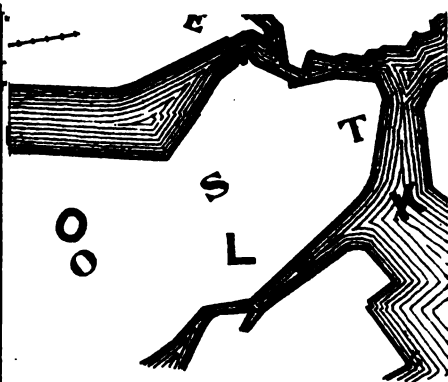
The Act required the Board also to take charge of, keep safe, use and maintain the Chestnut Hill Reservoir, until such time as it should abandon the same by notice in writing to the city. The Board deemed it wise, however, as well as in accordance with the judgment expressed by the mayor of the city of Boston, to make an absolute taking of the waters of the reservoir and that portion of the adjoining lands which are included within the roadway encircling the reservoir, leaving to the city as a parkway, and for the purposes of a park, the remainder of the Chestnut Hill Reservoir lands.

The Board found it necessary to take, in connection with the Chestnut Hill pumping station, a portion of the land easterly of the pumping station for the building of a new pumping station.

IV. ADMISSION OF OTHER MUNICIPALITIES INTO THE METROPOLITAN WATER DISTRICT.

In accordance with the application made by the city of Quincy, that city was formally admitted into the Metropolitan Water District on June 24, 1897. A payment of the nominal sum of \$5 was required, and the city, for the consideration of \$4,000, conveyed to the Commonwealth a parcel of land on Forbes Hill, containing about 5 acres, together with the right to use for the purposes of a public street a strip of land which had been laid out by the city from Adams Street to Forbes Hill. The city also agreed that water might be furnished by the Board to the city either from a reservoir and stand-pipe on Forbes Hill or from the pipes which were to be laid by the Board from Chestnut Hill Reservoir to Forbes Hill.

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The Board determined that, instead of constructing an iron tank on the summit of Forbes Hill, with a capacity of 2,000,000 gallons, as originally contemplated in the report of 1895 of the State Board of Health, it was advisable to construct a stand-pipe and a reservoir, having a capacity of about 5,000,000 gallons, upon Forbes Hill; and, inasmuch as the lot conveyed by the city to the Commonwealth had been purchased as a playground or park for the people, that the Board would cause a footway to be constructed around the reservoir to be built, which should be, under proper restrictions, open to the citizens of Quincy as a resort and point of observation. While the works proposed will necessitate some increase in the cost of construction, they will have a greater storage capacity and provide more fully for the wants of the future, and will also afford a greater protection against accidents and emergencies, and present a more attractive architectural appearance. The Board found the city willing to co-operate in this improvement, and to bear a proper proportion of the additional expense necessitated.

The town of Nahant has made application for admission into the Metropolitan Water District, and the Board has caused considerable investigations to be made in regard to ascertaining the best method of supplying water to the town. It is expected that arrangements will be made during the coming year by which the town will be formally admitted into the District.

Measures have been also taken by the town of Stoneham toward the admission of that town into the Metropolitan District, and investigations are in progress relative to the manner in which water can be supplied to the town, and as to the increased expense, if any, which may be occasioned.

Conferences have been had with the selectmen of Swampscott, with a view to the admission of that town also into the District, although it is without the limit of the towns which it is provided shall be admitted on complying with the terms proposed by the Board.

V. FINANCIAL STATEMENT.

(1) *Cost of the Work.*

A brief general résumé is here given of the expenditures made in the various operations of the Board:—

Summary of Expenditures.

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
<i>Wachusett Dam and Reservoir,</i>	\$805,455 94	\$1,766,056 96
<i>Wachusett Aqueduct,</i>	1,224,461 64	1,523,156 11
<i>Sudbury Dam and Reservoir,</i>	1,329,964 22	2,676,989 42
<i>Distribution system,</i>	1,183,361 22	1,787,865 58
<i>Other work and operations : —</i>		
Pipes, valves, castings, etc., sent to stock yards and not yet used,	133,386 84	276,702 70
Pipe line connection of Framingham Reser- voir No. 1 with Framingham Reservoir No. 3,	15,642 84	15,642 84
Investigations of existing water works sys- tems,	6,330 84	6,647 57
Settlements on account of diversion of water, and expenses connected with the same,	623,503 95	839,644 51
Administration and general expenses, . .	30,327 74	73,039 87
Totals,	\$5,352,435 23	\$8,965,745 56

The Board herewith presents, in accordance with the requirements of the Act of the Legislature, in abstract, a detailed account of its receipts, expenditures, disbursements, assets and liabilities, during the thirteen months beginning with the first day of December, 1896, and ending with Dec. 31, 1897.

This account is made for a period of thirteen months ending with December 31 and not ending with November 30, as in previous reports, because a much fuller statement can be made of the season's operations by ending the account with the calendar year.

(2) Expenditures.

The total amount of expenditures for the thirteen months beginning Dec. 1, 1896, and ending Dec. 31, 1897, is \$5,352,435.23, and the total amount from the time of the organization of the Board, July 19, 1895, is \$8,965,745.56. The general character of these expenditures is as follows : —

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
<i>Administration.</i>		
Commissioners,	\$15,166 67	\$34,700 27
Secretary and auditor,	6,657 80	14,273 13
Clerks and stenographers, . . .	5,143 30	10,262 32
Legal services,	—	2,334 00
Travelling,	319 63	483 22
Stationery and printing,	771 72	2,540 32
Postage, express and telegrams, .	202 86	490 11
Furniture and fixtures,	381 65	2,885 79
Alterations and repairs of building, .	197 43	1,703 74
Telephone, lighting, heating, water, and care of building,	1,068 72	2,206 90
Miscellaneous expenses,	417 96	1,160 07
	\$30,327 74	\$73,039 87
<i>Engineering.</i>		
Chief engineer and department en- gineers,	\$25,021 24	\$49,241 08
Principal assistant engineers, . .	18,380 31	33,596 87
Engineering assistants,	131,323 94	233,252 40
Consulting engineers,	5,000 00	10,361 10
Inspectors,	54,800 37	74,141 33
Architects,	2,221 36	2,221 36
Railroad and street car travel, . .	2,864 63	6,991 07
Wagon hire,	5,114 66	7,607 62
Stationery and printing,	3,344 41	7,777 69
Postage, express and telegrams, . .	956 99	1,951 22
Engineering and draughting instru- ments and tools,	3,687 74	13,539 22
Engineering and draughting supplies,	3,528 82	9,458 30
Books, maps, and photographic sup- plies,	934 17	2,133 98
Furniture and fixtures,	1,886 77	9,650 36
Alterations and repairs of building, — main office,	227 53	2,382 47
Alterations and repairs of building, — sub-offices,	399 78	415 84
Telephone, lighting, heating, water and care of building, — main office,	1,564 33	2,936 78
Telephone, lighting, heating, water and care of building, — sub-offices,	2,286 63	3,924 09
Rent of offices and other buildings, .	797 10	2,002 53
Field offices and sheds,	166 87	616 64
Clinton office building,	6,230 85	9,866 87
Unclassified supplies,	510 44	3,806 75
Miscellaneous expenses,	1,187 40	3,494 79
	272,436 34	491,370 35
<i>Amounts carried forward,</i>	\$302,764 08	\$564,410 22

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
<i>Amounts brought forward,</i>	\$302,764 08	\$564,410 22
<i>Construction.</i>		
Preliminary work (borings, soundings, test pits and other investigations):—		
Advertising,	\$554 74	\$1,974 00
Labor,	26,003 58	49,783 49
Medical services, analyses, etc., .	111 50	545 33
Travelling,	746 66	1,457 38
Rent,	6 00	34 00
Water rates,	1,060 32	1,958 13
Freight and express,	134 68	374 04
Jobbing and repairing,	6 29	322 58
Tools, machinery, appliances and hardware supplies,	2,249 79	14,449 99
Castings and ironwork,	16 40	87 27
Iron pipe and valves,	957 37	2,854 22
Blasting supplies,		31 60
Paint and coating,	12 02	135 83
Fuel, oil and waste,	195 10	458 94
Lumber and field buildings,	991 93	4,626 48
Brick, cement and stone,	114 60	168 19
Sand, gravel and filling,	37 50	195 05
Municipal and corporation work, .	40 07	40 07
Unclassified supplies,	320 60	918 42
Miscellaneous expenses,	71 00	112 30
	33,630 15	80,627 31
Contracts, Wachusett Reservoir:—		
Joseph Gennaro, Section 1,	\$9,288 36	\$9,288 36
Neill McBride, Section 2,	9,251 72	9,251 72
	18,540 08	18,540 08
Contracts, Wachusett Aqueduct:—		
E. D. Smith & Co., Section 2,	\$84,283 20	\$108,808 20
E. D. Smith & Co., Section 3,	166,323 60	204,713 10
Silvio Casparis, Section 4,	103,570 93	113,874 05
Silvio Casparis, Section 5,	87,431 34	97,710 42
Silvio Casparis, Section 6,	113,746 72	122,494 45
Silvio Casparis, Section 7,	113,011 58	128,721 35
Jones, Pollard & Co., Section 8,	47,022 32	64,699 30
Silvio Casparis, Section 9,	156,328 16	171,041 07
Silvio Casparis, Section 10,	106,361 92	170,061 24
Moulton & O'Mahoney, Section 11,	106,102 76	107,081 96
W. A. Murtfeldt Company, covering Assabet Bridge,	1,261 00	1,261 00
J. W. Bishop & Company, superstructure terminal chamber,	3,621 00	3,621 00
	1,089,064 53	1,293,587 14
<i>Amounts carried forward,</i>	\$1,443,998 84	\$1,957,064 75

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
<i>Amounts brought forward,</i>	\$1,443,998 84	\$1,957,064 75
<i>Construction—Con.</i>		
<i>Contracts, Sudbury Reservoir:—</i>		
Moulton & O'Mahoney, Sudbury Dam,	\$86,153 00	\$297,482 60
Auguste Saucier, . Section A,	32,468 04	33,150 03
Moulton & O'Mahoney, Section B,	15,173 35	55,477 93
Malone & Strang, . Section C,	30,454 58	81,070 83
Auguste Saucier, . Section D,	13,067 59	41,567 41
Charles Linehan, . Section E,	9,678 96	32,802 86
Newell & Snowling, Section F,	8,179 18	26,272 55
Charles Linehan, . Section G,	5,728 67	16,738 23
Moulton & O'Mahoney, Section H,	9,509 30	34,486 72
Harry P. Nawn, . Section I,	33,781 58	70,343 26
Moulton & O'Mahoney, Section J,	13,989 51	43,754 13
Blagen & Bush, . Section K,	32,071 42	53,972 60
Moulton & O'Mahoney, Section L,	56,162 88	78,864 00
Harry P. Nawn, . Section M,	71,021 64	91,560 02
Thomas Nevins & Son, Section N,	17,978 60	55,227 98
Washburn & Washburn, Section O,	53,481 95	72,618 73
Harry P. Nawn, . Section P,	44,890 24	71,710 99
Washburn & Washburn, Section Q,	68,248 12	98,512 66
Henry Parsons, . iron fence,	11,200 42	16,342 96
John Berry, . filter beds,		896 79
Holbrook, Cabot & Daly, stone arch bridge,	12,850 78	33,400 21
New York, New Haven & Hartford Railway Company, temporary bridge,	2,656 74	6,387 80
R. D. Wood & Co., sluice gates,	4,918 06	4,918 06
J. W. Bishop & Co., gate house,	17,437 92	17,437 92
John Evans & Co., . granite finial,	350 00	350 00
Holbrook, Cabot & Daly, circular dam,	4,550 27	4,550 27
	656,002 80	1,339,897 54
<i>Contracts, distribution system:—</i>		
Malone & McHale, . Section 1,	\$2,795 30	\$2,795 30
Curnan & Hochstadter, Section 2,		39,517 92
MacRitchie & Nichol, Sections 3 and 10,	30,624 51	30,624 51
C. A. & C. E. Trumbull, Section 4,	5,142 72	5,142 72
Snyder & Williams, Sections 4 and 11,	23,868 49	48,469 33
MacRitchie & Nichol, Section 5,	34,522 01	34,522 01
Moore & Co. and W. H. Ward, Section 6,	4,788 53	4,788 53
<i>Amounts carried forward, .</i>	\$101,741 56	\$165,860 32
	\$2,100,001 64	\$3,296,962 29

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward, .</i>	\$101,741	56 \$2,100,001	64	\$165,860 32 \$3,296,962 29
<i>Construction — Con.</i>				
<i>Contracts, distribution system — Con.</i>				
Dennis F. O'Connell, Section 6,	2,900	14		16,644 84
C. H. Eglee Co., . Sections 6 and 8,	61,381	92		61,381 92
C. H. Eglee Co., . Sections 7 and 13,	12,612	22		33,943 05
E. W. Everson & Co., Section 9,	14,762	19		14,762 19
H. A. Hanscom & Co., Sections 11 and 18,	29,502	19		29,502 19
A. W. Bryne Construction Co., Section 13,	25,443	19		25,443 19
Collins & Ham, . Section 14,	9,246	28		11,759 81
J. H. McKnight, . Section 15,	1,427	63		11,966 06
George Goodhue, . Section 16,	2,408	24		4,925 11
H. A. Hanscom & Co., Section 16,	1,166	93		1,166 93
H. A. Hanscom & Co., Section 17,	2,534	72		2,534 72
Collins & Ham, . Section 18,	8,564	26		10,682 97
Cheney & Trumbulls, Section 18,	771	41		771 41
E. W. Everson & Co., Section 19,	18,834	07		18,834 07
Saucier & O'Brien, . Section 21,	9,938	69		9,938 69
Bruno & Salomone, Section 23,	8,464	96		8,464 96
Samuel W. Frescoln, Section 24,	6,310	26		6,310 26
R. D. Wood & Co., iron pipe and special castings,	91,857	60		299,276 90
McNeal Pipe and Foundry Com- pany, . iron pipe and special castings,	157,493	97		311,484 04
Warren Foundry and Machine Company, iron pipe and special castings,	115,124	72		222,954 63
Camden Iron Works, . iron pipe and special castings,	295,496	37		295,496 37
Addyston Pipe and Steel Company, iron pipe and special castings,	30,473	48		30,473 48
Chelmsford Foundry Co., iron pipe and special castings,	1,108	02		1,841 61
Howard Harrison Iron Company, iron pipe and special castings,	93,034	46		156,628 28
Josiah H. Long, . . valves,	11,731	70		14,008 00
Camden Iron Works, . valves,	8,874	00		8,874 00
Kennedy Valve Manufacturing Company, . . . valves,	9,554	00		9,554 00
New Jersey Steel and Iron Com- pany, . . . steel work,	1,091	55		2,132 55
<i>Amounts carried forward, .</i>	\$1,133,850	73 \$2,100,001	64	\$1,787,616 55 \$3,296,962 29

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward,</i>	\$1,133,850 73	\$2,100,001 64	\$1,787,616 55	\$3,296,962 29
<i>Construction—Con.</i>				
Contracts, distribution system— <i>Con.</i>				
C. H. Eglee Company, gate house at Spot Pond,	14,356 69		14,356 69	
C. A. Dodge & Co., additional Chestnut Hill pumping station,	13,243 50		13,243 50	
David H. Andrews, building pipe bridge over Boston & Maine Railroad at Somerville,	2,497 00		2,497 00	
Cheney & Trumbulls, abutments for pipe bridge over Mystic River at Medford,	2,141 11		2,141 11	
Harry P. Nawn, laying pipe at Framingham from dam 3 to dam 1,	12,561 67		12,561 67	
		1,178,650 70		1,832,416 52
<i>Additional work:—</i>				
Labor,	\$61,618 21		\$71,653 59	
Professional services,	329 60		335 60	
Travelling,	81 78		221 92	
Rent,	1,353 64		1,653 64	
Water rates,	30 50		35 00	
Freight and express,	969 75		1,209 55	
Jobbing and repairing	709 90		1,004 28	
Tools, machinery, appliances, and hardware supplies,	8,827 16		10,352 13	
Castings and ironwork,	6,625 75		7,128 74	
Iron pipe and valves,	6,242 02		7,519 21	
Blasting supplies,	315 72		315 72	
Paint and coating,	1,078 99		2,136 88	
Fuel, oil, and waste,	688 72		701 35	
Lumber and field buildings, . .	12,263 14		13,824 54	
Drain pipe,	554 14		627 83	
Brick, cement, and stone, . . .	849 51		1,077 31	
Sand, gravel, and filling, . . .	1,351 99		1,715 89	
Municipal and corporation work, .	33,460 12		35,709 92	
Police service,	40,407 65		60,358 01	
Sanitary inspection,	1,866 07		3,443 82	
Unclassified supplies,	814 42		903 47	
Miscellaneous,	483 92		548 53	
Judgments,	1,000 00		1,000 00	
		181,922 70		223,476 93
Legal and expert services and ex- penses,		390 58		3,667 90
<i>Amounts carried forward, . . .</i>		\$3,460,965 62		\$5,356,523 64

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
<i>Amounts brought forward,</i>	\$3,460,965 62	\$5,366,523 64
<i>Real Estate.</i>		
Legal and expert:—		
Legal services,	\$161 00	\$4,456 31
Conveyancer and assistants,	19,266 61	33,451 80
Experts,	8,914 28	13,789 40
Appraisers,	2,863 01	3,327 79
Court expenses,	20 02	20 02
Counsel expenses,	43 25	43 25
Conveyancing supplies,	884 84	1,909 31
Conveyancing expenses,	715 24	1,139 56
Miscellaneous expenses,	18 25	79 20
Settlements,	685,666 75	1,563,654 75
Taxes and tax equivalents,	568 83	2,194 85
Care and disposal,	781 77	1,095 35
	719,903 85	1,625,161 59
<i>Damages.</i>		
Legal services,	—	\$1,130 67
Settlements,	\$400 00	400 00
	400 00	1,530 67
<i>Claims on Account of Diversion of Water.</i>		
Legal services,	—	\$3,749 98
Expert services,	\$4,197 29	7,267 70
Settlements,	611,850 00	814,850 00
	616,047 29	825,867 68
<i>Purchase of Water Works.</i>		
Legal services and expenses,	\$351 63	\$1,895 14
Reimbursement, city of Boston,	554,766 84	1,154,766 84
	555,118 47	1,156,661 98
Total,	\$5,352,435 23	\$8,965,745 56

The expenditures have been distributed among the various objects or works as follows:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
General administration, applicable to all parts of the work,	\$30,327 74	\$73,039 87
<i>Wachusett Dam and Reservoir.</i>		
Wachusett dam, engineering,	\$14,951 07	\$27,142 42
preliminary work,	1,290 51	23,539 02
<i>Amounts carried forward,</i>	\$16,241 58	\$30,327 74
	\$50,681 44	\$73,039 87

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward,</i> .	\$16,241 58	\$30,327 74	\$50,681 44	\$73,039 87
<i>Wachusett Dam and Reservoir — Con.</i>				
Wachusett dam, contracts, tempo- rary works,	7,340 74		7,340 74	
<i>additiona work,</i> temporary works,	58,489 65		58,489 65	
North dike, engineering, . . .	12,167 61		14,928 92	
preliminary work, . . .	17,685 17		24,413 08	
contracts, . . .	12 37		12 37	
South dike, engineering, . . .	414 28		894 95	
preliminary work, . . .	65 88		2,436 56	
Removal of soil, engineering, . .	13,647 80		19,823 74	
preliminary work, . . .	10,345 96		11,225 11	
contracts, . . .	11,411 72		11,411 72	
additional work, . . .	178 00		178 00	
Relocation of railroads, engineering,	1,409 75		2,797 36	
Roads and bridges, engineering, .	5,683 74		8,149 38	
preliminary work, . . .	300 43		300 43	
contracts, roads, . . .	7,128 36		7,128 36	
additional work, . . .	534 75		534 75	
Real estate :—				
Engineering,	8,843 19		31,009 96	
Legal and expert,	25,081 44		41,367 54	
Mill property and water rights, .	246,000 00		1,011,000 00	
Other property for reservoir and margins :—				
Clinton,	63,886 00		81,236 00	
Boylston,	71,160 00		91,065 00	
West Boylston,	206,020 00		261,345 00	
Sterling,	19,420 75		20,095 75	
Outlying property :—				
Clinton,	-		3,609 00	
Boylston,	-		370 00	
West Boylston,	1,100 00		2,030 00	
Taxes, care and disposal, . . .	486 77		653 49	
Damages, loss of wages, West Boylston,	400 00		400 00	
Legal and expert (except in real estate),	-		1,130 67	
		805,455 94		1,796,056 96
<i>Wachusett Aqueduct.</i>				
Engineering,	\$78,912 70		\$139,902 86	
Preliminary work,	119 78		3,545 79	
Contracts, tunnel,	235,643 03		292,093 07	
masonry aqueduct, . . .	61,135 86		820,592 27	
<i>Amounts carried forward, . . .</i>	\$1,005,811 20	\$835,783 65	\$1,255,094 01	\$1,899,056 96

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward,</i> . . .	\$1,005,811 39	\$835,783 68	\$1,256,094 01	\$1,839,096 83
<i>Wachusett Aqueduct — Con.</i>				
Contracts, Assabet bridge, . . .	48,495 78		66,172 76	
terminal chamber, . . .	7,978 60		7,978 60	
open channel, . . .	106,102 76		107,081 96	
Additional work, . . .	35,103 83		44,007 60	
Legal and expert, . . .	1,081 69		9,393 34	
Real estate, property and ease- ments:—				
Property in Berlin, . . .	3,232 50		8,357 50	
Property in Clinton, . . .	12,100 00		17,700 00	
Property in Northborough, . . .	3,195 00		3,567 50	
Property in Marlborough, . . .	1,057 50		1,607 50	
Property in Southborough, . . .			700 00	
Taxes, care and disposal, . . .	302 59		505 34	
		1,224,461 64		1,523,156 11
<i>Sudbury Dam and Reservoir.</i>				
Dam, engineering, . . .	\$10,534 89		\$19,554 28	
preliminary work, . . .	33 78		498 00	
contracts, core wall, . . .	9,096 30		50,198 57	
embankments, . . .	33,955 48		95,211 83	
masonry section, . . .	43,101 22		152,072 20	
superstructure, . . .	17,787 92		17,787 92	
sluice gates and iron work, . . .	4,918 06		4,918 06	
additional work, . . .	8,204 33		10,882 15	
Reservoir, engineering, . . .	35,059 20		64,896 12	
preliminary work, . . .	20 50		353 62	
contracts, removal of soil and deepening, . . .	481,532 31		868,914 68	
roads and rail- roads, . . .	61,061 24		145,347 22	
circular dam, . . .	4,550 27		4,550 27	
additional work, . . .	21,407 85		37,956 69	
Protection and improvement of sup- ply:—				
Engineering, . . .	918 35		1,769 98	
Preliminary and additional work,	11 00		102 27	
Contracts, . . .	—		896 79	
Legal and expert, . . .	2,048 44		3,785 56	
Real estate, property in Southborough,	38,258 00		38,258 00	
Marlborough, . . .	2,137 00		2,137 00	
taxes, care and disposal, . . .	561 24		2,131 37	
Reimbursement, city of Boston, . . .	554,766 84		1,154,766 84	
		1,329,964 22		2,676,989 42
<i>Amounts carried forward,</i> . . .		\$3,390,209 54		\$6,039,242 36

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward,</i>		\$3,390,209 54		\$6,039,242 36
<i>Pipe Lines and Connections between Framingham Dams No. 3 and No. 1.</i>				
Engineering,	\$2,229 69		\$2,229 69	
Preliminary work,	239 58		239 58	
Contracts,	12,736 84		12,736 84	
Additional work,	436 73		436 73	
		15,642 84		15,642 84
<i>Distribution System.</i>				
Low service:—				
Pipe lines and connections,				
engineering,	\$32,920 77		\$74,959 53	
preliminary work,	303 85		8,360 59	
contracts,	644,743 67		1,086,077 94	
additional work,	37,061 35		48,178 28	
Pumping station,				
engineering,	3,180 02		5,845 14	
preliminary and additional work,	75 08		83 08	
Reservoir, engineering,				
preliminary work,	6,669 90		9,687 00	
contracts, gate chamber,	776 31		1,197 84	
additional work,	12,004 48		12,004 48	
Real estate,	2,447 40		2,586 08	
Legal and expert,	900 00		3,386 50	
	468 34	741,551 17	2,010 00	1,254,376 46
Northern high service:—				
Pipe lines, engineering,				
preliminary work,	\$12,220 29		\$21,711 47	
contracts,	110 09		1,483 46	
additional work,	162,144 92		231,776 91	
Pumping station,				
engineering,	5,119 78		6,666 40	
preliminary and additional work,	510 96		1,360 02	
Reservoir, engineering,	10 00		41 00	
preliminary and additional work,	1,169 94		3,882 85	
Real estate,	440 91		924 73	
Legal and expert,	13,200 00		13,200 00	
	107 87	195,034 76	240 65	281,287 49
Southern high service:—				
Pipe lines, engineering,				
preliminary work,	\$15,528 68		\$17,331 68	
contracts,	1,852 23		1,852 23	
	194,447 81		194,447 81	
<i>Amounts carried forward,</i>	\$211,828 72	\$4,342,438 31	\$213,631 92	\$7,590,549 15

	For Thirteen Months, ending Dec. 31, 1897.		From Beginning of Work, and ending Dec. 31, 1897.	
<i>Amounts brought forward,</i> .	\$211,828 72	\$4,342,438 31	\$213,631 92	\$7,590,649 15
<i>Distribution System — Con.</i>				
<i>Southern high service — con.</i>				
Pipe lines, additional work, . .	11,046 98		11,046 98	
Pumping station,				
engineering, . . .	6,015 25		6,583 65	
preliminary and additional work, . .	130		130 15	
contracts, building, .	13,243 50		13,243 50	
Reservoir, Quincy, engineering and preliminary work,	209 64		940 32	
Real estate,	4,000 00		4,000 00	
Legal and expert,	213 01		2,161 34	
		246,687 25		251,737 86
Extra high service, engineering, .	. . .	88 04	. . .	463 77
Pipes, valves, castings, etc., sent to stock yards, and not used on the works Dec. 31, 1897, . . . .	. . .	133,386 84	. . .	276,702 70
<i>Claims on Account of Diversion of Water.</i>				
Engineering and preliminary work, .	\$5,585 40		\$11,905 57	
Legal and expert,	6,068 55		12,888 94	
Settlements,	611,850 00		814,850 00	
		623,503 95		839,644 51
<i>Examination of Existing Water Works.</i>				
Engineering,	\$3,574 18		\$3,697 58	
Legal and expert,	2,756 66		2,949 99	
		6,330 84		6,647 57
Total, . . . . .	. . .	\$5,352,435 23		\$8,966,745 56

(3) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the thirteen months ending Dec. 31, 1897, is \$9,249.40, and the total amount from the time of the organization of the Board is \$12,649.97. The sources of these receipts are as follows : —

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Forfeiture for contracts awarded, but not executed,	—	\$500 00
Rents from real estate,	\$5,961 98	8,009 63
Sales of real estate and buildings,	783 00	1,242 00
Land products,	993 95	1,315 20
Labor, tools and supplies,	1,457 61	1,498 36
Payments on account of admission into the Metropolitan Water District,	5 00	5 00
Unclassified receipts,	47 86	79 78
Totals,	\$9,249 40	\$12,649 97

The foregoing receipts have been credited to the various objects or works as follows:—

	For Thirteen Months, ending Dec. 31, 1897.	From Beginning of Work, and ending Dec. 31, 1897.
Wachusett Reservoir	\$5,242 50	\$6,026 34
Wachusett Aqueduct,	83 54	162 42
Sudbury Reservoir,	2,564 95	4,602 80
Distribution system,	1,353 41	1,853 41
Admission into the Metropolitan Water District,	5 00	5 00
Totals,	\$9,249 40	\$12,649 97

(4) *Assets.*

The value of the assets is given, as far as practicable, at cost prices:—

Desks, chairs, safes, drafting tables, plan cases, type-writing machines, electrical fittings, and general office fixtures and supplies,	\$14,800 00
Transits, levels, planimeters, scales and other engineering instruments; drafting paper and general drafting supplies, outfits for cement testing, blueprinting, photography, chemical analyses, etc.,	18,800 00
Atlases, maps, portfolios and reference books,	1,600 00
Railroad and electric road tickets,	1,080 00
Horses, vehicles, farm machinery and stable supplies,	1,600 00
Revolvers, handcuffs, belts and other police supplies,	1,700 00
Engines, pumps, boilers, derricks, diamond and other drills, lumber, field buildings, tools and general construction supplies,	31,420 00
Pipes, valves, castings, etc., at stock yard,	254,000 00
	\$320,200 00

There are numerous note and calculation books, studies, plans, etc., of great value to the Board, to which no stated value can be assigned; also real estate in the site of the proposed Wachusett Reservoir; the Sudbury Dam and the completed Sudbury Reservoir, with outlying lands in Southborough and Marlborough; the Wachusett Aqueduct, and many miles of pipe line.

(5) *Liabilities.*

Unpaid bills,	\$24,800 00
Due on monthly pay rolls,	5,600 00
Approximate amount to be paid for police service in Southborough,	2,000 00
Reserved on approved monthly estimates for work done (not due until completion of contracts),	205,112 96
	<hr/>
	\$237,512 96

In addition to the above, there are amounts which will be due on various contract sections, from the time of each last monthly estimate to Dec. 31, 1897, for the remaining real estate settlements in the Sudbury Reservoir, for unsettled claims on account of takings for the Wachusett Aqueduct, and for a taking in the Wachusett Reservoir.

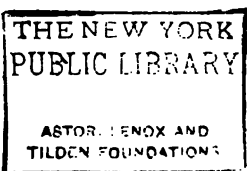
VI. THE WORK ACCOMPLISHED AND FOR THE FUTURE.

The city of Boston, in the year 1895, had but just begun to construct in Southborough and Marlborough the larger reservoir contemplated for the more complete storage of the waters of the Sudbury water-shed.

It was the first duty of the Metropolitan Water Board to build an aqueduct from the site of the proposed dam at Clinton on the South Branch of the Nashua River to the new reservoir in Southborough and Marlborough, to complete this reservoir and connect it with the Sudbury Aqueduct in use by the city of Boston, and to construct main water pipes from the Chestnut Hill Reservoir and pumping station, where the waters of the Cochituate and Sudbury systems are received in Boston, to the various portions of the Metropolitan Water District, and to Spot Pond, which was to become a distributing reservoir for the northern portion of the District.



WACHUSETT AQUEDUCT — DAM AT LOWER END OF OPEN CHANNEL — FORMER SITE OF SAWIN'S DAM AND MILL POND.



By the construction of the aqueduct, the completion of the unfinished reservoir, and the laying of the water mains, the waters flowing in the South Branch of the Nashua River could be diverted and added to the water supply of the city of Boston and other portions of the Metropolitan Water District.

The scheme for adding the waters of the South Branch of the Nashua River to those of the Cochituate and Sudbury systems of the city of Boston, and to make them available for the supply of the Metropolitan Water District, had, at the end of the year 1897, progressed almost to completion. The Wachusett Aqueduct, consisting of 2 miles of tunnel, 7 miles of masonry conduit and 3 miles of open channel, had been built, and the Nashua River connected with the Sudbury Reservoir at Southborough. The Sudbury Dam and Reservoir, begun by the city of Boston, had been completed, with a storage capacity of 7,500,000,000 gallons and a superficial area of 2 square miles. This reservoir had been connected with the Sudbury Aqueduct of the city of Boston, and by it with the Chestnut Hill Reservoir. Great main pipes, generally 48 inches in diameter, had been laid to Spot Pond, and connections had been made with the greater part of the Metropolitan Water District. Spot Pond had been made available as a storage and distributing reservoir, and additional pumping facilities were in process of construction to afford the additional service to be required. A temporary dam had been erected in Clinton, and connection had been nearly completed between the river and the aqueduct for the diversion of the water of the river into the aqueduct.

The entire water works for the supply and storage of water of the city of Boston, west of the Chestnut Hill Reservoir, and Spot Pond and the lands immediately surrounding the pond were taken by the Board on the first day of January, 1898; and the Board then began supplying water to the city of Boston and several other cities and towns in the Metropolitan Water District.

Mystic Lake, which had been repeatedly pronounced by the State Board of Health and the Boston Water Board as affording water too impure for drinking purposes, was abandoned as a source of water supply.

In carrying out this great undertaking, much disturbance has necessarily been occasioned by the tearing up of streets and the

invasion of lands, not only within the District itself, but in cities and towns outside of the limits of the District. Homes, lands and other valuable properties have necessarily been taken from individuals, and a large community has been broken up. It is but justice to say that few complaints have been uttered by those who have been affected by these operations, and in general all sections have seemed to unite in the endeavor to speed the progress of the work.

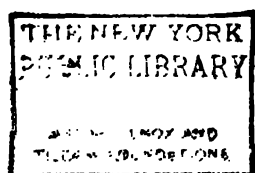
The actual consumption of water in the Metropolitan Water District had reached the capacity in a very dry year of the various sources of water supply of the city of Boston and the other towns and cities of the Metropolitan District, if the consumption had not actually exceeded this capacity. It is calculated that by the completion of the Sudbury Reservoir the capacity of the sources of supply of the Metropolitan District in a very dry year will be increased to 69,000,000 gallons daily; but the daily consumption of water in the District had reached 79,000,000 gallons in the year 1897. By the diversion of the waters of the South Branch of the Nashua River through the Wachusett Aqueduct, which will be accomplished early in the year 1898, the capacity of the Metropolitan Water System will be still further increased to at least 101,000,000 gallons daily.

Sufficient has already been accomplished to insure for the more immediate future a supply of water to the Metropolitan Water District, so that apprehensions of any serious trouble from a scarcity of water in the near future may now be dispelled.

The construction of the Wachusett Dam at Clinton and of the Wachusett Reservoir, which will afford a storage capacity surpassed in the world only by the Periyar Reservoir in India; the erection of new pumping stations at Chestnut Hill, at Spot Pond and in other portions of the Metropolitan Water District; the building of additional distributing reservoirs; the improvement of Spot Pond, so as to adapt it for use as a distributing reservoir for the northern portion of the District; the building of a high-service distributing reservoir in Middlesex Fells; and the laying of additional main pipes in portions of the Metropolitan Water District, — are works of large magnitude, and will require several years for their accomplishment.



SUDBURY DAM WITH GATE HOUSE — UPPER SIDE.



The report of the chief engineer, explaining in detail the operations of the engineering department, and containing various explanations and tables, is herewith presented.

Respectfully submitted,

HENRY H. SPRAGUE.
WILMOT R. EVANS.
HENRY P. WALCOTT.

Boston, Jan. 1, 1898.

REPORT OF THE CHIEF ENGINEER.

To the Metropolitan Water Board.

GENTLEMEN : — The following is a report of the operations of the engineering department for the year ending Dec. 31, 1897.

ORGANIZATION.

The organization of the engineering department remains substantially the same as at the date of the last report. In the force reporting directly to the chief engineer there has been but one change : Morris Knowles, office assistant, resigned on May 13, to accept a position in Pittsburg, Pa., and John N. Ferguson, his first assistant, was promoted to fill the vacancy.

The list of engineers reporting directly to the chief engineer is as follows : —

DEXTER BRACKETT, .	. Engineer, Distribution Department.
DESMOND FITZGERALD, .	. Engineer, Sudbury Department.
THOMAS F. RICHARDSON, .	. Engineer, Dam and Aqueduct Department.
HIRAM A. MILLER, .	. Engineer, Reservoir Department.
REUBEN SHIRREFFS, .	. Principal Office Assistant.
JOHN N. FERGUSON, .	. Office Assistant.

Joseph P. Davis and A. Fteley have continued to act as consulting engineers.

F. H. Snow, formerly city engineer of Brockton, who has had a valuable experience in the construction and maintenance of a system of sewage disposal for that city, was specially engaged to make investigations and a report upon the purification of the sewage of Clinton.

H. B. Burley, formerly city engineer of Nashua, N. H., was specially engaged to make examinations and a report upon a system for diverting into the Merrimac River a part of the sewage of that city, which now flows into the Nashua River.

Both of these engineers have reported from time to time regarding the progress of their work, but neither had completed his final report at the end of the year.

Owing to the large amount of construction which has been done during the year, it has been necessary to increase the engineering force, and to increase to a greater extent the number of inspectors employed upon the work. At the beginning of the year the engineering force numbered 146, and reached a maximum in September, when 200 engineers were employed. In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed to inspect pipe making, pipe laying, machinery, masonry and earth work. The maximum number so employed at any one time during the year was 44.

Gangs of men under the immediate direction of foremen and under the general direction of the engineers have been employed upon the temporary works at the Wachusett Dam, to clear trees and brush from the land purchased for the Wachusett Reservoir, to make borings, to repair roads, to handle water pipes and to do other minor work. Toward the end of the year another day-labor force was organized, to fill, clean and test the water pipes which had been laid, and to arrange for the maintenance of the water-pipe system when it should be put in operation on Jan. 1, 1898.

FORCE EMPLOYED ON WORKS.

The largest force employed upon the works at any one time during the year was in the early part of August, 1897, as follows:—

	Men.	Horses.
Contractors' force:—		
Wachusett Aqueduct,	1,897	425
Wachusett Reservoir,	79	26
Sudbury Dam and Reservoir,	809	214
Pipe laying,	512	70
	<hr/> 3,297	<hr/> 735
Day-labor force,	179	22
Engineers, including engineer-inspectors,	199	—
Inspectors, not engineers,	40	—
	<hr/> 3,715	<hr/> 757

CONTRACTS.

A detailed statement of the contracts made and pending during the year 1897 is given in Appendix No. 1. The following statement gives a summary of all of the formal contracts from the beginning of the work to the end of 1897 :—

PORTION OF WORK.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir,	2	\$23,938 06
Wachusett Aqueduct,	14	1,420,239 23
Sudbury Reservoir, contracts assumed from the city of Boston (uncompleted portions).	11	576,930 11
Sudbury Reservoir, contracts made by the Metropoli- tan Water Board.	15	835,943 80
Distribution department,	67	2,220,733 57
Totals,	109	\$5,077,784 77

Number of contracts made and assumed in 1896, 56

Number of contracts made in 1897, 53

109

Amount of contracts made and assumed in 1896, including only
the uncompleted portions of contracts assumed from the city of

Boston (approximate), \$3,853,568 93

Amount of contracts made in 1897 (approximate), 1,224,215 84

\$5,077,784 77

Number of contracts completed in 1896, 13

Number of contracts completed in 1897, 57

Number of contracts uncompleted Dec. 31, 1897, 39

109

Amount of contracts completed in 1896, \$651,449 77

Amount of contracts completed in 1897, 3,013,206 37

\$3,664,656 14

Amount of contracts uncompleted Dec. 31, 1897 (approximate), 1,925,128 63

\$5,589,784 77

Deduct for work done on 11 Sudbury Reservoir contracts by city
of Boston, 512,000 00

\$5,077,784 77

Value of work done by contract to dates of December, 1896, estimates,	\$2,029,022 12
Value of work done by contract from dates of December, 1896, estimates, to Dec. 31, 1897,	2,679,951 79
	<hr/>
	\$4,708,973 91
Value of work remaining to be done on uncompleted contracts Dec. 31, 1897,	368,810 86
	<hr/>
	\$5,077,784 77

It is worthy of note that the 70 contracts completed in 1896 and 1897, amounting to \$3,664,656.14, have all been settled without any controversy, and although many of them were completed at a loss to the contractor, in no case has there been a failure to finish the work. Of the 39 contracts remaining uncompleted at the end of 1897, the work was practically or wholly finished before the end of the year on 18 contracts, amounting to \$1,002,601.08; but they are marked as uncompleted, because the final settlements had not been made. It is expected that in all of these cases an amicable settlement will be reached.

RESERVOIR DEPARTMENT.

HIRAM A. MILLER, *Department Engineer.*

The work in this department has continued to be mainly of a preliminary nature. The preliminary work at the site of the North Dike, which, at the beginning of the year, was in charge of Mr. T. F. Richardson, engineer of the dam and aqueduct department, was later in the year, when the work of construction required the whole of Mr. Richardson's time, placed in charge of Mr. Miller. The report of this work for the whole year is given under the head of the reservoir department.

The organization of the force has been in general the same as for the previous year. The assistant engineers are Charles A. Bowman, Moses J. Look, Harry J. Morrison and Ernest H. Baldwin. Chester W. Smith was also engaged in this department until May 10, when he was transferred to the dam and aqueduct department, and Mr. Baldwin was promoted to fill the vacancy caused by this transfer. The engineering force in this department has varied from 16 to 24, but, as much drafting and other work has been done by

employees of the dam and aqueduct department, the total number actually employed on the work of the reservoir department has varied from 21 to 31.

The main office was removed, on January 25, from Pierce's Block, Clinton, to a new building erected by the Metropolitan Water Board for an engineers' office in the same town. A branch office has been maintained at West Boylston throughout the year.

NORTH DIKE.

The work of obtaining the full information required for the locating and designing of this dike has been found more difficult than was expected, and consequently the boring gangs were kept steadily at work until Dec. 13, 1897, when the work of boring was completed. Four hundred and eleven borings were made between Dec. 1, 1896, and Dec. 13, 1897, on the easterly portion of the dike and 387 on the westerly portion, making a total of 798 borings, having an aggregate depth of 61,246 feet. Including the borings made before Dec. 1, 1896, the total number is 1,071, having an aggregate depth of 92,165 feet, equal to $17\frac{1}{2}$ miles.

Prof. W. O. Crosby has continued to advise with regard to the method of conducting these borings, and has done a great deal of work in classifying the results of the borings and assisting in the preparation of profiles showing the stratification of the ground.

The experiments upon the filtration of water through soils and sand have been continued. Other experiments have been made to determine the relative permeability of surface soil, as taken from the ground, and after the organic matter has been burned out of it. The burning of the organic matter was done in the mining department of the Massachusetts Institute of Technology. Many other experiments and examinations, relative to the use of soil in the dike and to the design of the dike, have been made.

Additional topography has been taken on all of the area covered by the examinations for the dike. A topographical plan of the easterly portion has been completed, and a similar plan of the westerly portion is now in progress. Longitudinal and cross-sections, showing borings, have been plotted, and many tracings and blue prints of them have been made.

After locating the centre line of the dike, borings were taken every 50 feet along this line. The designs for the construction

of the dike are very nearly completed, and estimates have been made of the quantities of excavation and of material of various kinds required for the construction of the easterly portion, and similar work for the westerly portion is far advanced. Much study has been given to the practical methods of constructing the dike.

LAND SURVEYS.

Since the date of the last report the total area surveyed has been 4,302 acres, or $6\frac{3}{4}$ square miles, making the total area surveyed to date 15,825 acres, or approximately $24\frac{3}{4}$ square miles. Of this total, 13,461 acres, or 21 square miles, have been plotted upon sectional plans, 24 inches high and 36 inches wide, to a scale of 100 feet to an inch. Seventy-six of these plans are now completed and tracings of them have been made, and 22 are now in progress. These plans have also been reduced to a scale of 300 feet to an inch. There are now 14 plans on this scale, from which tracings and blue prints have been made.

REMOVAL OF SOIL.

The work preliminary to the removal of soil from the reservoir has been continued. Careful estimates have been made of the total amount of soil to be excavated. A large amount of work has been done toward staking out the reservoir into squares of 500 and 1,000 feet on a side, to serve as a basis for cross-sectioning the reservoir, and in establishing permanent benches in the reservoir. This work is a necessary preliminary, in order to determine accurately the amount of soil removed from the reservoir by contractors.

A force of men has been employed during the greater part of the year cutting brush, wood and timber from the land purchased by the Board for the reservoir, and in removing the wood and timber and burning the brush. The number of acres cleared by this force has been approximately 640, and 370 acres have been burned over.

The taking down of the dam of the Lancaster Mills, which will be referred to under the head of the dam and aqueduct department, laid bare, temporarily, the bottom of a mill pond which had been flooded for many years; and, in order to remove the soil from this portion of the bottom of the reservoir, a contract was made with Neill McBride of Brighton, Mass., on September 15. Under this contract 69,000 cubic yards of soil were removed from $28\frac{1}{2}$ acres

and piled in spoil banks. Work on this section was begun September 22. The maximum force employed was 146 men and 73 horses.

In addition to the contract work, a small day-labor force was employed from November 6 to December 2, in removing stumps, logs and brush from the bed of the Nashua River below the level of the flow line of the Lancaster Mill Pond.

RELOCATION OF ROADS.

The work of locating the new roads around the reservoir, to take the place of those which will be submerged by filling it, has been continued. Four miles of located roads have been staked out, and estimates of the quantity of material required for building 3 miles of road have been made. At one point on the south side of the reservoir a section of the road 6,800 feet long has been built. This road is a part of a new road which will take the place of the so-called river road between Clinton and Boylston Centre. It has been completed, with the exception of the surfacing, which will be built in 1898, after the embankments have had time to consolidate. The contract for this road, which is known as Section 1 of the reservoir, was made with Joseph D. Gennaro of Boston on July 14. Work was commenced on July 26, and completed on December 6. The maximum force employed was 82 men and 26 horses. The construction of the embankments upon this road required 50,500 cubic yards of earth, of which 29,000 were obtained from the cutting on the line of the road and 21,500 yards from the reservoir by stripping off the soil.

ADDITIONAL SURVEYS AND LEVELS.

Ten additional stations have been added to the triangulation system.

Starting from the precise bench marks previously established, 172 intermediate benches have been established for use during the construction of the reservoir.

Surveys have been made of three suggested modifications of routes for the relocation of the Central Massachusetts Railway.

In order to obtain further information with regard to the amount of storage in the existing reservoirs within the water-shed of the South Branch of the Nashua River above the main dam, a survey was made early in 1897 of all of the larger ones. This survey in-

cludes 11 storage reservoirs, and a plan of each reservoir has been made. Gages have been established, which are read from time to time, to show the amount of water stored in or drawn from these reservoirs.

A survey of the Nashua River and the mill ponds upon it, extending from Oakdale, at the head of the Wachusett Reservoir, to East Pepperell, a distance of $32\frac{3}{4}$ miles, was made in 1896. The results of this survey have, during 1897, been plotted on 8 sheets, each sheet showing, both in plan and profile, one mill privilege and the mill pond and river above it, up to the next privilege. One of the mill privileges is on Muddy Brook, a branch of the river, in Boylston. In connection with each of these plans a report has been made, giving the area of the mill pond at the flow line and one and two feet below this line, the number, size and make of the water wheels, and the actual fall from the surface of the pond to where the tail-race of the mill joins the river.

Extensive surveys and investigations of locations of sewers and sites of filter-beds have been made by the engineers of the reservoir department, in connection with a study of the best method of disposing of the sewage of Clinton, and maps of Clinton and portions of Lancaster and Bolton have been made from these surveys. Two hundred and eighty test pits have been dug, and 14 borings, having an aggregate depth of 488 feet, have been made to determine the character of the ground at points where it was thought that it might be feasible to filter the sewage, or to obtain material from which to make filter-beds.

DAM AND AQUEDUCT DEPARTMENT.

THOMAS F. RICHARDSON, Department Engineer.

The work in this department has related mainly to the construction of the Wachusett Aqueduct, and the year has been a very busy one. The organization of the engineering force has been substantially the same as during the previous year, although the increase in the amount of work required a very considerable increase in the number of engineers and inspectors. Horace Ropes, Alexander E. Kastl and Charles E. Wells are respectively the engineers of the first, second and third divisions of the aqueduct; Ernest G. Hopson is head draftsman; and David Hinckley is in charge of gagings and

investigations, devoting a portion of his time to work in the reservoir department. Chester W. Smith, who was transferred to this department from the reservoir department May 10, was placed in charge of the temporary dam and other works at the river. The engineering force, including engineer-inspectors, in this department at the beginning of the year was 44; the number was increased from time to time as the increase in the work demanded, until August 21, when the total engineering force, including engineer-inspectors, was 73, and there were, in addition, 18 inspectors of masonry. At the end of the year the engineering force numbered 54, and there was 1 inspector of masonry.

The main office of the department is in the new building erected for an engineers' office in Clinton, and a branch office has been maintained at Northborough for the use of the engineers of the second and third divisions of the aqueduct.

WACHUSETT DAM.

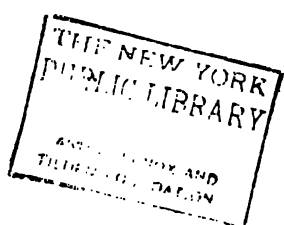
The plans for the construction of this dam have progressed very slowly, because the time of the engineering department has been so fully occupied by work which it was more important to complete promptly. As soon as it was found that it would not be feasible to let contracts for the main dam and its protective dams in 1897, it was decided to construct a temporary dam above the site of the main dam, to divert the water into the aqueduct, and to serve as an up-stream protective dam during the excavation for the foundations of the main dam.

Temporary Works. — As the water in the Lancaster Mill Pond at the site of the temporary dam had a depth of fully 20 feet, it was necessary to take down the Lancaster Mills dam before beginning the work. By the terms of an agreement with the Lancaster Mills Corporation, only the upper 6 feet of the dam could be taken down until provision had been made for pumping clean water from a point above the site of the temporary dam into the canal at the Lancaster Mills. The work of removing the dam was begun June 1, and the taking down of the upper 6 feet was completed June 19, the work being rendered more difficult by the high water in the river.

On June 14, as soon as the water in the mill pond had lowered sufficiently, the work of excavating the trench for laying a 24-inch cast-iron pipe from a point above the site of the temporary



WACHUSETT RESERVOIR — TEMPORARY DAM WITH WASTE WAY AND CONDUIT CONNECTING WITH TUNNEL.



dam to the canal of the Lancaster Mills was begun. As it was necessary that this work should be done rapidly, the foremen and men for doing the work were obtained from E. D. Smith & Co., the contractors for constructing the tunnel. Pipe laying was begun June 23, and was finished July 31. Prior to the latter date, a centrifugal pump had been put in place upon a raft, above the site of the temporary dam, and a boiler had been located on the opposite shore and connected with the pump. This pump was started at 11 P.M., July 31, and since that date has been used continuously to pump clean water to the Lancaster Mills. The average amount of water pumped daily has been 1,325,000 gallons.

On August 2 the taking down of the Lancaster Mills dam was continued, and an opening about 25 feet in width was carried nearly to the bottom of the dam, the work being finished August 28. A considerable amount of additional work was done subsequently, from time to time, in order to protect the bridge pier and abutment just above the dam from danger during freshets.

The work of constructing the temporary dam was begun at its ends during the week ending July 31, and was continued until the end of the year. This dam is an embankment of earth, with a row of sheet piling in the centre to serve as a cut-off. It has passing through it two wooden flumes, one 7 feet 2 inches wide and 7 feet 7 inches high, which is to extend to the upper end of the Wachusett Aqueduct, and the other 40 feet wide and 16 feet high, to carry that portion of the water of the river not diverted into the aqueduct. It is proposed to extend the larger flume so that it will carry the water of the river past the excavation to be made for the permanent masonry dam.

As it is necessary to raise the water nearly to the top of the large flume in order to divert the water through the aqueduct, provision has been made for inserting gates and stop planks in it. It is essential, during the construction of the foundations of the main dam, that there should be no overflow at the temporary dam, except into the large flume; and it is also essential that the flow through this flume should not be obstructed in times of freshet either by stop planks or gates, or even by stop-plank grooves, which might collect such larger obstructions as stumps, logs and floating ice; consequently, special machinery was provided, by which in a short time all of the stop planks, gates and stop-plank

grooves could be removed, leaving a free passage through the flume 40 feet wide and 16 feet high.

The small flume, which leads from the temporary dam to the head of the aqueduct, is so located that its foundation is several feet below the original surface of the rock, where the flume crosses the line of the masonry dam. This location added greatly to the difficulty of building the flume at the present time, as it required an excavation 40 feet deep, but will make it very much easier to maintain the flume while the masonry dam is being constructed.

In order to connect this flume with the portion of the aqueduct built in tunnel, it was necessary to excavate from the surface to the end of the aqueduct as built in tunnel, to continue the aqueduct 19 feet to its upper end and to build a portion of the permanent gate house.

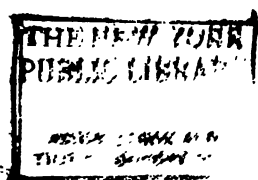
The river was turned through the large flume November 4, and the dam was substantially finished before the end of the year. Considerable work, however, remains to be done to complete the small flume through the deep cut.

WACHUSETT AQUEDUCT.

In 1896, contracts were made for constructing the Wachusett Aqueduct, comprising 2 miles of tunnel through rock; 7 miles of masonry aqueduct, including a bridge across the Assabet River; and 3 miles of open channel, following in general the course of a brook and extending to the upper end of the Sudbury Reservoir. By the provisions of each of these contracts the work was to be completed Dec. 1, 1897. At the beginning of the year 1897, a considerable amount of work had been done on all of the sections; but it was only on sections 2 and 3, which included the tunnel, and section 8, the Assabet Bridge, that the rate of progress was up to the requirements of the specifications. It is, therefore, very gratifying to be able to state that all of the work, with the exception of the open channel, was substantially completed before the end of the year, and much of it considerably ahead of the contract time. The delay at the open channel is less serious than the same delay in the construction of the masonry aqueduct, since the work remaining to be done is almost wholly earth and rock work, which can be prosecuted in cold weather. The work upon the open channel is so far advanced that it could be put in use, although it is desirable that it should be finished before any water is run through it.



WACHUSETT AQUEDUCT—SECTION OF TUNNEL IN ROCK WITH BOTTOM LINING.



Sections 2 and 3,—Rock Tunnel.

Contractors, E. D. Smith & Co.; date of contracts, Feb. 12, 1896; amount of contracts, \$371,321; length of tunnel, 10,331 feet; width where lined with brickwork, 12 feet 2 inches; where unlined, 13 feet 6 inches; height where fully lined with brickwork, 10 feet 10 inches; where only the bottom is lined, 11 feet 10 inches; length of aqueduct not in tunnel, 1,010 feet; width, 11 feet 6 inches; height, 10 feet 6 inches.

At the beginning of the year 1897, the work of excavating the tunnel was progressing rapidly, but none of it had been lined.

The length of tunnel excavated from each shaft and from the portal to the headings, and the dates at which the headings met, are as follows:—

PORTION OF TUNNEL.	Length of Tunnel to Meeting of Headings.	Date of Meeting of Headings. 1897.
	Feet.	
Shaft No. 1, west,	26	—
Shaft No. 1, east,	1,420	} May 2.
Shaft No. 2, west,	1,505	
Shaft No. 2, east,	1,517	} April 15.
Shaft No. 3, west,	1,228	
Shaft No. 3, east,	1,407	} March 25.
Shaft No. 4, west,	1,050	
Shaft No. 4, east,	1,083	} March 24.
Portal,	1,095	
Total,	10,331	

NOTE.— The distances given are from centres of shafts.

The removal of the benches and the trimming of the tunnel continued until August 14, and after this date a small amount of trimming was done at the shafts, and some loose rock was removed from the tunnel.

Twenty-one feet of tunnel, extending from the westerly side of Shaft No. 1, as far as it was feasible to construct the aqueduct in tunnel, were not included in the contract, and were excavated under a special agreement.

The plans of the tunnel provided for lining the whole of the bottom, so as to make a smooth invert, with an inclination of 1 foot in 5,000; but provision was made for arching the tunnel only where the existing conditions of the rock made it necessary, or where the rock was of such a character that it seemed likely to deteriorate.

In order to determine which portions should be arched, careful examinations were made by Prof. W. O. Crosby, geologist, Massachusetts Institute of Technology, and by the engineers. Professor Crosby not only made a detailed and thorough personal examination, but took specimens of rock every 10 feet along the length of the tunnel, which he carefully examined, and which are preserved in the Clinton office. His reports of the results of his examinations and of the specimens taken formed the principal basis for determining which portions of the tunnel should be arched.

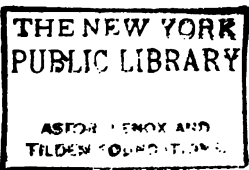
Near the Nashua River, where the tunnel runs a short distance down stream from and nearly parallel with the proposed Wachusett Dam, a very heavy section of lining was adopted, and the masonry was built solidly to the bottom, sides and top of the rock tunnel, except in cases where there was timbering which could not be removed. In such cases, as much timbering was removed as possible, and cement grout was pumped in behind the lining and behind the timber, to thoroughly fill all vacant spaces. This section is strong enough to resist water pressure, and was made practically water-tight. In other portions of the tunnel the lining and arching were adopted only for the purpose of supporting the rock, and not to keep out water.

Six hundred and eighty-six linear feet of the tunnel required timbering when the tunnel was excavated, to prevent the rock from falling. In these timbered sections it was not often feasible to remove the frames or the top lagging, but the side lagging was generally taken out.

Where the tunnel was arched, the masonry was filled in solidly against the rock sides of the tunnel to a point rather more than one-half way up the arch, and this solid masonry at the side served as an abutment for the upper 90 degrees of arch. The spaces over the arch, except at the heavy section near the dam, already referred to, were packed with stone taken from the tunnel. The arch generally consisted of 3 rings of brickwork, which gave it a thickness of $12\frac{1}{2}$ inches, but under the shafts and wherever else it seemed



WACHUSETT AQUEDUCT—LOWER END OF TUNNEL—UNFINISHED.



necessary, the arch was made thicker. The lengths of the different kinds of lining are given in the following table:—

	Feet.
Heavy section near dam,	349
Five or six ring arch near shafts,	39
Four-ring arch,	706
Three-ring arch,	3,684
Total length arched,	4,778
Lined on the bottom only,	5,553
	<u>10,331</u>

A view in the tunnel where only the bottom is lined, and a view of the end of one of the arched portions of the tunnel, may be seen opposite pages 14 and 50.

The invert of the tunnel, the side lining for 12½ inches from the interior of the tunnel, and the arch, were built of brick masonry, laid in mortar, which was composed of one part of American natural cement and one and one-half parts of sand up to the springing line, and of two parts of sand to one of cement above the springing line. The backing behind the 12½ inches of brickwork at the sides was generally made with stone from the tunnel, laid in mortar composed of two parts of sand and one part of cement.

The dates when the brick lining of various portions of the tunnel were started and finished are given in the following table. No account is taken of small amounts of work at the shafts, which were finished later.

PORTION OF TUNNEL.	Lining Started.	Lining Finished.
Shaft No. 1, west,	September 14.	September 22.
Shaft No. 1, east,	May 13.	September 27.
Shaft No. 2, west,	June 15.	August 30.
Shaft No. 2, east,	May 25.	August 21.
Shaft No. 3, west,	April 7.	August 9.
Shaft No. 3, east,	May 7.	September 24.
Shaft No. 4, west,	March 30.	October 7.
Shaft No. 4, east,	January 20.	October 6.
Portal,	May 4.	August 16.

At Shaft No. 1 the lining of the tunnel was carried continuously through the shaft, but, as the upper part of the shaft would be removed by future excavation for the dam, the shaft was not filled up. Shafts No. 2 and No. 3 have been closed by building a brick arch at or near the bottom of each, and filling in about 10 feet of earth; also by building additional arches across the shafts near the top of the rock, and filling with earth to the surface of the ground. The unfilled space in each of these shafts is drained so that the water cannot accumulate in it. Shaft No. 4 has been kept open by building a circular ring of brick masonry, 6 feet in diameter, and filling the remainder of the shaft. On the top of the shaft a small, circular gray brick house, 7 feet 6 inches in diameter inside, has been built to facilitate access to the tunnel. The last masonry built by the contractor was the granite coping of this shaft, which was set November 20. The 1,010 linear feet of masonry aqueduct not in tunnel on Section 3 were completed October 30.

A statement of the bricks and cement used in the construction of the tunnel, and of the cost per linear foot of the tunnel and masonry aqueduct, are given subsequently.

West Berlin Water Supply.—The construction of the tunnel drained several wells at West Berlin, and, in order to furnish a substitute for the water formerly furnished by these wells, a well 10 feet deep and 10 feet in diameter inside of the curbing was dug on land west of the tunnel and south of the Central Massachusetts Railroad, and covered with a wooden roof. From this well a 2-inch galvanized-iron pipe, 5,600 feet long, was laid through private land and in the highway, to supply water to five houses and one watering trough at the highway. The work of constructing this water supply was begun November 18, and water was supplied to the houses on December 27.

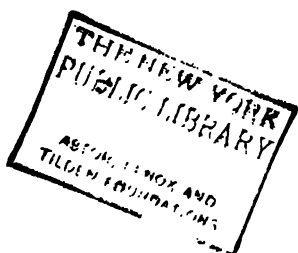
Sections 4, 5, 6, 7, 9 and 10, — Masonry Aqueduct.

Contractor, Silvio Casparis; date of contracts, May 9, 1896; amount of contracts, \$834,197.06; length of aqueduct, 35,475 feet; width, 11 feet 8 inches; height, 10 feet 6 inches; inclination of aqueduct, 1 foot in 2,500.

These six contracts include very nearly all of the masonry aqueduct not in tunnel. The amount of work done in 1896 was, as stated in last year's report, much less than the amount required by the terms of the contracts. In the winter, as no work could be done upon the masonry, comparatively little could be accom-



WACHUSETT AQUEDUCT — SECTION ON EMBANKMENT — IN PROCESS OF CONSTRUCTION.



plished. The contractor continued to work, however, as vigorously as possible during this season of the year, in providing bricks, broken stone, screened gravel and sand for the masonry to be built the coming season, and in excavating where it was feasible to excavate.

In 1896, sections 5 and 6 were sublet, with the assent of the Board, to Smith & Burden of Long Island City, N. Y. These contractors became insolvent toward the end of the year and abandoned the work, and on Feb. 19, 1897, the Board assented to a second subletting of these sections to the Standard Construction Company of Columbus, O. All of the other sections remained under the direct control of Mr. Casparis.

The work of constructing the masonry of the aqueduct was resumed as early in the spring as the weather would permit, and the whole work was carried on very vigorously, so that the masonry was completed before cold weather. The dates of resuming work upon the masonry and of laying the last aqueduct masonry upon the various sections are given in the following table:—

SECTION.	WORK UPON AQUEDUCT MASONRY.	
	Resumed.	Finished.
4,	During week ending April 3.	October 12.
5,	During week ending April 17.	November 19.
6,	During week ending April 17.	November 18.
7,	During week ending April 3.	October 19.
9,	During week ending April 10.	October 30.
10,	During week ending April 3.	October 27.

The aqueduct is built of concrete and brick masonry. The bottom and side walls are of American natural cement concrete, lined with one or more rings of brick masonry, and the arch of Portland cement concrete, without a brick lining. The American cement concrete is composed of five parts of screened gravel or broken stone, two parts of sand and one part of cement; the Portland cement concrete of four and one-half parts of gravel or stone, two and one-half parts of sand and one part of cement. The brick

masonry in nearly all cases was laid in American cement mortar composed of two parts of sand and one part of cement.

The cross-sections of the masonry of the aqueduct were shown on Plan No. 3 of the report of last year. The section was varied to suit the conditions at different places. Under ordinary conditions, where the excavation was in earth, what is known as the regular section was built. This is illustrated by a plate opposite page 16.

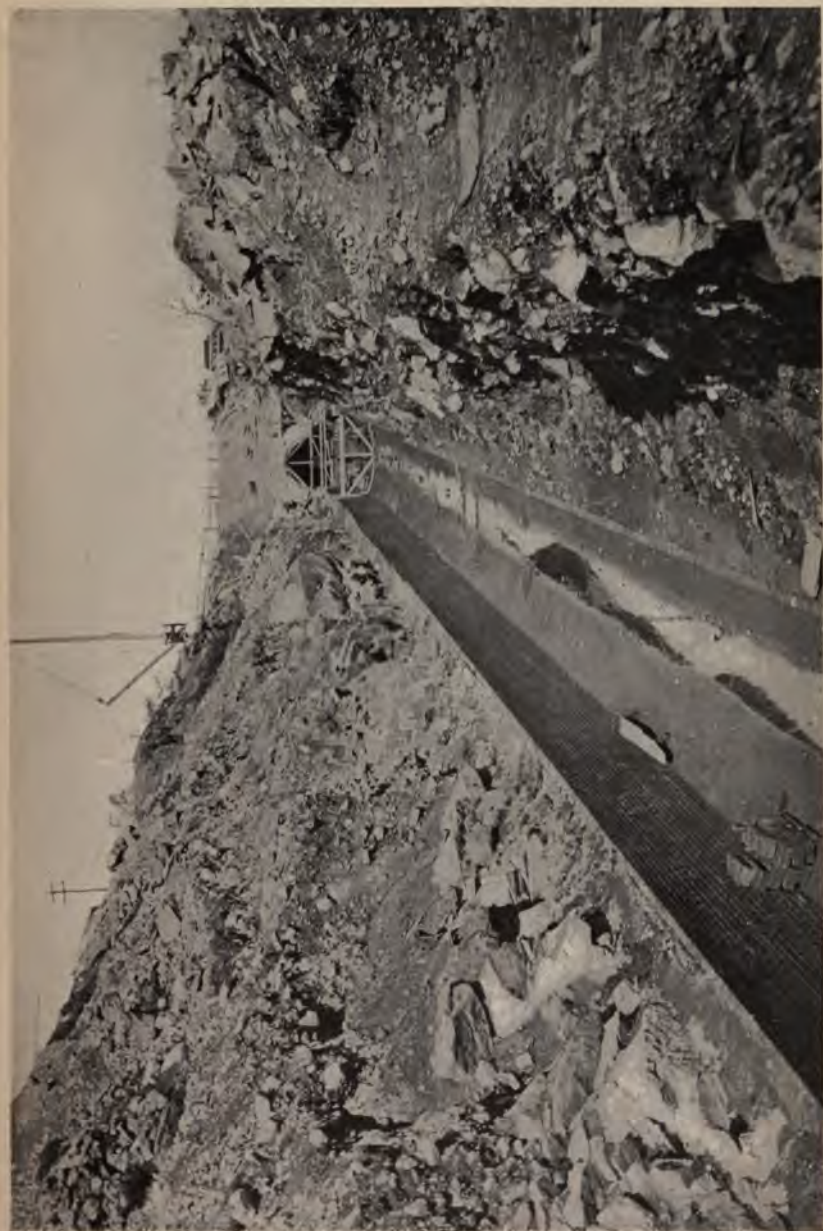
In rock or hard earth excavation, where the sides would stand without caving, the concrete side walls were made much smaller, and filled out to the sides of the excavation. Where the aqueduct is founded upon an embankment of earth, the concrete side walls were carried down to a level, giving a very broad base for the aqueduct, and permitting iron rods, with washers at each end, to be placed in the concrete just beneath the brick invert.

Where there was water in the bottom of the trench, a central wooden drain and a light platform, consisting of boards nailed to light sills, were used, the boards sloping down to the central drain. Where there was little water, the boards were grooved on each edge, so as to form small channels to carry the water to the drain; and where there was more water, two layers of boards were used, the upper layer being fluted upon the under side, thus furnishing many channels of considerable size to convey the water. These light platforms were required only on sections 9 and 10, as the excavations upon other sections were generally above the water level.

After building the aqueduct, the inside of the arch was plastered with a thin coating of Portland cement and two coats of Portland cement wash were applied to the brick side walls. At first the Portland cement wash was used upon the arch as well as upon the side walls, but the thin plastering was found to give better results. These additional coatings were applied mainly for the purpose of making the masonry more nearly water-tight, but they also made the arch smoother.

In addition to the coating of the arch and sides, the brick invert was given two coats of cement wash, where the aqueduct was on an embankment of earth.

In building the arch, the centres were oiled to keep the cement from adhering to them, but before plastering, this oil, if it remained on the inside of the arch, was removed by washing with concentrated lye.



WACHUSETT AQUEDUCT — SECTION IN CUT — IN PROCESS OF CONSTRUCTION.

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ASTOR LENOX AND
TILDEN FOUNDATION

This plastering and cement wash were not provided for in the contracts for building the aqueduct, but were done by the contractor as extra work. It required 647 barrels of cement for the arch and sides, and the cost of the finished work was \$8,114, or about 22½ cents per linear foot. The cement wash on 3,368 feet of invert required 22 barrels of cement, and cost 6 cents per foot.

In the construction of the aqueduct few special appliances were used for making the earth excavation. Cable ways were used to a limited extent on sections 9 and 10, but as a rule were not very satisfactory, although in some places they did good work. Power drills were generally used for the rock excavation. All concrete was mixed by hand. Screened gravel was used in making the concrete, when it was available, but in 1897 it was necessary to use large quantities of broken stone. Six stone crushers were in operation upon these sections of the aqueduct. In some cases elevated screens were used for screening gravel, with success. In one case—on Section 9—the screens were supplied with material by the use of a cable way.

A statement of the bricks and cement used, and of the cost of the masonry aqueduct per linear foot, are given subsequently.

Superstructures.—Upon Section 4 and Section 10 of the aqueduct small superstructures were built under separate contracts. The one on Section 4 is a small granite building covering a large man-hole, where apparatus for measuring the flow in the aqueduct with a current meter is being installed. The contract, dated Nov. 8, 1897, was made with the New England Granite Works of Concord, N. H. The work of erecting the building was begun on November 29 and finished on December 22. The amount of the contract was \$1,584.

The superstructure upon Section 10 covers the terminal chamber of the masonry aqueduct. The contract, dated Oct. 18, 1897, was made with J. W. Bishop & Co. of Worcester, Mass. The work of erecting the building was begun on November 15, and finished on December 16. The stone used in the building came from the quarry of the New England Granite Works at Concord, N. H. The amount of the contract was \$4,260. A view of the terminal chamber and its superstructure may be found opposite page 58.

Section 8, — Assabet Bridge.

Contractors, Jones, Pollard & Co.; date of contract, June 16, 1896; amount of contract, \$64,766; length of bridge, 359 feet; length of masonry aqueduct not on bridge, 30 feet; character of structure, 7 granite arches (1 over a road and 6 over a mill pond) supporting an aqueduct; span of arches, 29.5 feet; height of arches above surface of mill pond, 17 feet.

The frontispiece gives a view of this bridge, which is now completed with the exception of the iron railing. The architectural features were designed by Reuben Shirreffs, principal office assistant.

The lower part of the aqueduct upon the bridge has the same form as the lower part of the aqueduct at other places, but the upper part is different, vertical walls covered with iron beams and brick arches being used upon the bridge, instead of the semi-circular arch.

When work was stopped for the season of 1896, all of the piers were finished to a point above the level of the water in the mill pond. Work was resumed on March 29, 1897, and the building of the masonry began April 12 and was finished September 1.

The stone used for the bridge was furnished by the New England Granite Works of Concord, N. H., and proved to be very satisfactory, both in quality and appearance.

The contractors for building the bridge completed it ahead of the contract time, and in a very satisfactory manner.

Lead Lining and Granolithic Covering.—In addition to the main contract for constructing the bridge, two small contracts were made, one for placing a continuous lining of sheet lead back of the 8 inches of brick masonry forming the interior lining of the aqueduct. The lead was purchased by the Commonwealth, but a contract for placing it and burning the sheets of lead together was made with Henry Sheldon of Lowell, Mass., on June 23. He began work July 6 and completed his contract July 31. The lead weighed 5 pounds to the square foot, and the sheets were 16 feet long and 9 feet wide. These were burned together without the use of solder.

The lead lining was provided for the purpose of preventing any leakage from the aqueduct, where it crosses the bridge, and it appeared to be absolutely water-tight when the work was completed.

In order to insure the permanence of the lead and to make satisfactory work, the bottom and sides of the aqueduct, against which



WACHUSETT AQUEDUCT — TERMINAL CHAMBER AT END OF COVERED AQUEDUCT.



the lead was to be placed, were smoothly plastered and then coated with asphalt paint. After the sheets of lead had been put in place and burned together they were covered with a thick coating of asphalt before the 8 inches of brick lining were put in place.

In order to protect the top of the bridge from the weather, to prevent the rain from soaking into the masonry and to make a suitable finish for the top of the bridge, it was covered with granolithic, laid on two layers of roofing felt coated with coal tar.

The contract for this work was made Sept. 24, 1897, with the W. A. Murtfeldt Company, which began work October 7 and finished placing the granolithic on November 6. Dyckerhoff Portland cement was used in making the granolithic. The amount of the contract was \$1,261.

The main and minor contracts for this bridge, including the cost of the lead used for the lining, amounted to \$68,544.30.

Section 11,— Open Channel.

Contractors, Moulton & O'Mahoney; date of contract, Sept. 22, 1896; amount of contract (approximate), \$142,850; length of section, 15,800 feet.

This section of the aqueduct, which extends from the terminal chamber of the masonry aqueduct to the upper end of the Sudbury Reservoir, and follows the general course of a brook which flowed into this reservoir, was under construction at the beginning of the year. By the terms of the contract it should have been finished on Dec. 1, 1897, but at the end of December considerable work remained to be done near the upper end of the channel. The unfinished work does not include any masonry, and can be prosecuted in the winter. The masonry, which included two small dams, four stone arch bridges to carry highways across the channel and three stone arch bridges for private ways, was begun June 1 and finished November 13. All of the masonry was done in a very satisfactory manner.

The channel is 20 feet wide on the bottom, and has side slopes of three horizontal to one vertical. The bottom and sides, where the material encountered was too fine to prevent erosion, were faced with coarse gravel.

For about four-fifths of a mile at the lower end of the channel it is located through an old mill pond. At this place the pond was

improved by removing the mud and soil, by deepening and by facing the slopes with gravel.

A view of a finished section of the open channel with one of the highway bridges crossing it, and a view of the lower dam, which was built on the location of the old mill dam, may be seen opposite pages 60 and 36.

The progress of the earth work upon this section has been seriously delayed by rainy weather and by the insufficient provision made by the contractors, by ditching and building flumes for taking care of so much water.

A much larger amount of rock was encountered in the excavations than was expected when the contract was made, and gravel for covering the slopes of the channel had to be hauled a long distance; for these and other reasons, the cost of the work will be materially increased above what was expected when the contract was let.

In making the excavations the contractors have had a steam shovel in operation most of the year, but the greater part of the work has been done by men shovelling into wheelbarrows, carts and sometimes into cars. The steam shovel has generally been used in connection with cars, which have been hauled up an incline by a stationary hoisting engine.

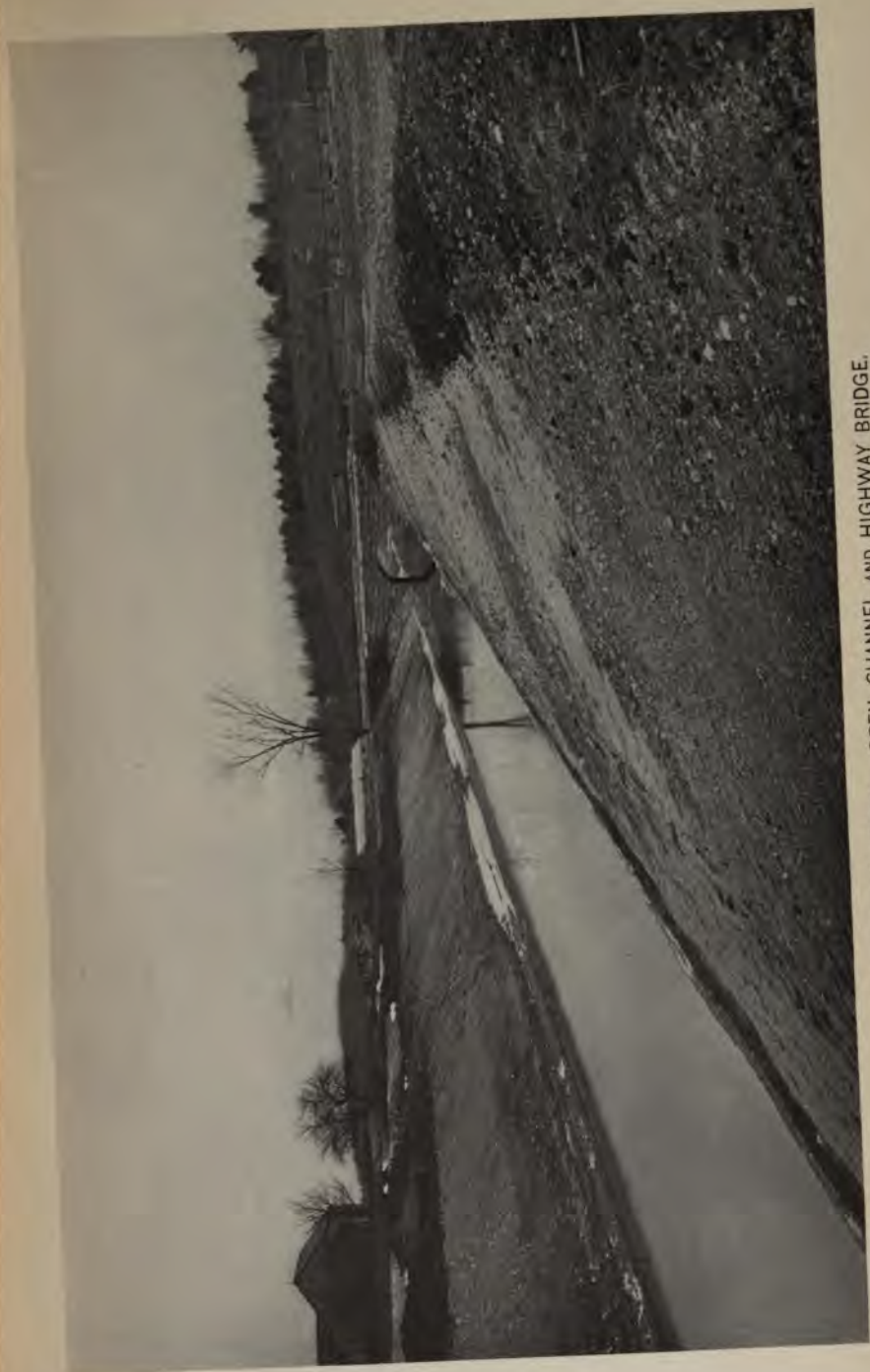
In some cases, particularly where rock or boulders have been encountered, derricks have been used for removing the material.

At two points along the line of the channel fine sand was encountered, which could not be excavated to the slopes proposed for the sides of the channel, and special measures had to be taken to hold the material while excavating and applying the gravel facing. The contract provided that, where it was necessary to do such special work as this, the contractor should be paid its cost, plus 15 per cent.

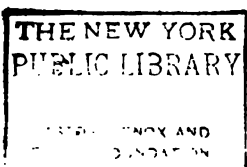
Force employed.

The largest force engaged on aqueduct construction in 1897 was during the week ending August 21, when 2,001 men and 467 horses were at work.

The maximum force engaged upon each of the various sections during the year was as follows : —



WACHUSETT AQUEDUCT — OPEN CHANNEL AND HIGHWAY BRIDGE.



SECTION.	Date.	Men.	Horses.
2,	March 4.	152	10
3,	February 17.	265	22
4,	June 16.	222	34
5,	June 8.	230	70
6,	September 28.	405	92
7,	May 14.	261	74
8,	June 1.	75	17
9,	August 11.	351	100
10,	August 31.	273	58
11,	December 10.	423	72

The total number of days' labor of men upon the aqueduct during 1897 was 371,434, and of horses 75,345.

Materials used.

In constructing the masonry of the aqueduct and the lining of the tunnel 12,250,000 bricks were used, also 112,901 barrels of American natural cement and 48,262 barrels of Portland cement, making a total of 161,163 barrels of cement. Of this total, 26,957 barrels were used in 1896 and 134,206 barrels in 1897.

Of the bricks used, about two-thirds were furnished by the Granite State Brick Company from Epping, N. H. Of the remaining one-third, by far the larger part were Star brick from Epping, N. H., and most of the others were furnished by the New England Steam Brick Company of Providence, R. I.

The cements used were as follows:—

<i>American natural cements:—</i>		Barrels.
Norton,		60,877
Hoffman,		43,024
Beach,		8,100
Other brands,		900
		<hr/> 112,901

Portland cements : —

	Barrels.
Atlas,	17,735
Giant,	15,094
Iron Clad,	5,575
Brooks-Shoobridge,	5,306
West Kent,	3,394
Other brands,	1,158
	<hr/> 48,262

Appendix No. 3 gives a summary of the tests of these cements.

Cost of Aqueduct.

The total amount of payments on account of the Wachusett Aqueduct to Dec. 31, 1897, was \$1,523,000. In order to obtain the total cost to December 31, there should be added to this sum about \$135,000, to cover a portion of the general expenses of administration and the liabilities incurred in connection with the construction of the aqueduct to this date. These liabilities are principally the amounts reserved on contracts to secure their fulfilment.

Further expenditures, which will not probably exceed \$100,000, will have to be made in order to complete the settlements for land taken and to finish the work upon the aqueduct. The work remaining to be done includes the completion of Section 11.

In accordance with the above statements, the approximate cost of the aqueduct will be \$1,758,000, making the cost per foot, including incidental expenses of every kind, except interest on the money invested, about \$28.

The *contract work* upon the tunnel has amounted to about \$33 per foot.

The *contract work* upon the masonry aqueduct has amounted to about \$24 per foot.

The *contract work* upon the Assabet Bridge and the lead lining have cost about \$191 per foot.

In addition to the contract work, the engineering, inspection, administration, land damages and preliminary and additional work, including minor contracts, will cost about \$5 per foot.

The above approximate figures are given at the present time to answer the inquiry often made as to the cost, and more particularly the cost per foot, of different portions of the aqueduct.

The cost of this aqueduct will be very small in proportion to its

capacity and the magnitude of the work. If the above approximate estimate of the cost of the final completion of the work is correct, it will be finished for \$507,000 less than its cost as estimated in the report of the State Board of Health upon a Metropolitan Water Supply.

Engineering and Miscellaneous.

While the active work of construction has required nearly all of the time of the engineers of the dam and aqueduct department, some other matters have received attention.

Relocation of Central Massachusetts Railroad.—Early in the year, additional surveys and estimates were made relative to the proposed relocation of this railroad.

South Dike.—Studies and estimates have been made to finally locate this dike, and estimates of the cost of the dike as finally located, are being prepared.

North Dike.—The borings and the experimental work at the site of this dike were under the charge of the dam and aqueduct department during the first part of the year, when they were transferred to the reservoir department. An account of the results of the investigations has been given under the head of that department.

SUDBURY DEPARTMENT.

DESMOND FITZGERALD, *Department Engineer.*

The work in this department during the year has been mainly the continuation of the construction of the Sudbury Dam and Reservoir, but in addition to this work an additional line of 48-inch pipes has been laid from Framingham Dam No. 3 to Framingham Dam No. 1, and a large number of plans have been prepared in connection with the taking of a portion of Boston's water works under the provisions of the Metropolitan Water Act.

The organization of the engineering force during the early part of the year was the same as in the previous year; later, as the work upon the different sections of the reservoir was completed, the force was diminished, and in some cases the engineers were transferred from the completed portions to other portions of the reservoir.

On Dec. 6, 1897, William C. Hall, the principal assistant of Mr. FitzGerald, died. He was a man of energy, ability and integrity, and had been connected for many years with the construction of reservoirs and other works for the city of Boston.

Edward S. Larned, division engineer, is now in charge, under Mr. FitzGerald, of the work of construction.

Ellery C. Appleton, Frank A. Bayley, Benjamin F. Goodnough, Oscar S. Heyer, Almon A. Platts, Daniel W. Cole, William Smiddy, Walter W. Patch and Bertram H. Davis are assistant engineers, and Fred F. Moore is draftsman. The total number in the engineering force at the end of the year was 25.

SUDBURY DAM.

This dam was designed and its construction was begun by the city of Boston for the enlargement of its water supply, and it was rather more than half done when taken, on Jan. 4, 1896, by the Commonwealth, under the provisions of the Metropolitan Water Act.

It is the largest of the dams of the Sudbury system, and is located on the Stony Brook Branch of the Sudbury River, about 1 mile north-easterly from the village of Fayville in the town of Southborough. Its length across the valley at the water line is 1,865 feet, and the maximum height of the water line above the surface of the ground is 65 feet.

Two views of this dam may be seen opposite pages 38 and 66.

In the central portion of the dam there is a masonry spillway 300 feet long, and at the northerly end of the spillway a gate chamber in the deepest part of the valley; all of this central portion is founded upon solid rock.

Between this masonry section and the sides of the valley there are earth embankments, containing core walls of concrete, which are carried down to bed rock, except at the extreme ends in the side hills, at which points the bed rock runs lower than it was thought necessary to go with the foundations. In order to make the core walls water-tight, they were plastered on the water side with Portland cement.

The embankments have a slope of two to one everywhere except at the lower portion of the down-stream side, where they are two and one-half to one.

On each side, part way down the slope of the embankments, there is a berm. On the up-stream side the face of the embankment above the berm is protected by a heavy layer of paving,

resting upon broken stone, while below the berm the protection is riprap, placed by hand to an even slope. The portions of the dam not protected by paving and riprap are covered with a thick layer of soil and are grassed.

At the beginning of the year there was only a small force upon the dam, engaged in laying paving. In the spring the laying of the crest stones of the spillway and the placing of soil were resumed. The work progressed slowly; the last crest stone was laid on August 3, and the whole of the contract work was completed on October 16.

The largest force employed upon the dam by the contractor at any time during the year was for the week ending July 3, when 97 men and 12 horses were at work.

The total amount of the contract was \$539,049.67.

The following table shows the principal quantities of work done in the construction of this dam:—

Earth excavation and refilling (cubic yards),	262,881
Soil excavated and placed in spoil banks (cubic yards),	31,203
Soil removed from spoil banks and placed on slopes (cubic yards),	18,727
Rock excavation (cubic yards),	16,873
Rubble stone masonry (cubic yards),	30,917
American cement concrete masonry (cubic yards),	15,594
Portland cement brick masonry (cubic yards),	403
Facing stone masonry (cubic yards),	4,840
Dimension stone masonry (cubic yards),	510
Riprap (cubic yards),	12,325
Paving (cubic yards),	1,858
Broken stone in place (cubic yards),	1,190
Plastering with Portland cement (square yards),	9,135
Hammer dressing (six-cut) (square feet),	7,007
Coping (linear feet),	443
Sodding (square yards),	980
Seeding (acres),	3.7

A contract for the construction of nine sluice gates, and their erection in the gate chamber, was made with Messrs. R. D. Wood & Co. of Philadelphia, on Sept. 17, 1896. The work under this contract was completed March 15, 1897. The lower gates were in position and closed on February 8. The gates and openings are so arranged that water can be taken from the reservoir at three different levels.

The gate chamber is surmounted by an attractive granite gate-house, designed by Wheelwright & Haven, architects, and built by J. W. Bishop & Co. of Worcester, Mass., under a contract dated April 9, 1897. The amount of the contract was \$17,437.92. The gate-house was completed October 1.

After the completion of the contract work upon the dam, a day-labor force was employed to clear and grade the grounds just below it, to lay a drain at the toe of the northerly embankment of the dam for the purpose of intercepting the leakage at this point and conveying it to a weir for measurement, to reconstruct the way, which was formerly a highway, leading from the present highway to the dam, and to remove the old buildings and farms along this way.

STURGEY RESERVOIR.

The improvement of the reservoir by the removal of the soil and the deepening of the shallow portions was begun by the city of Boston in 1894, and on Jan. 4, 1896, when the work was taken by the Metropolitan Water Board, one-sixth of the total quantity of earth to be removed from the reservoir had been removed.

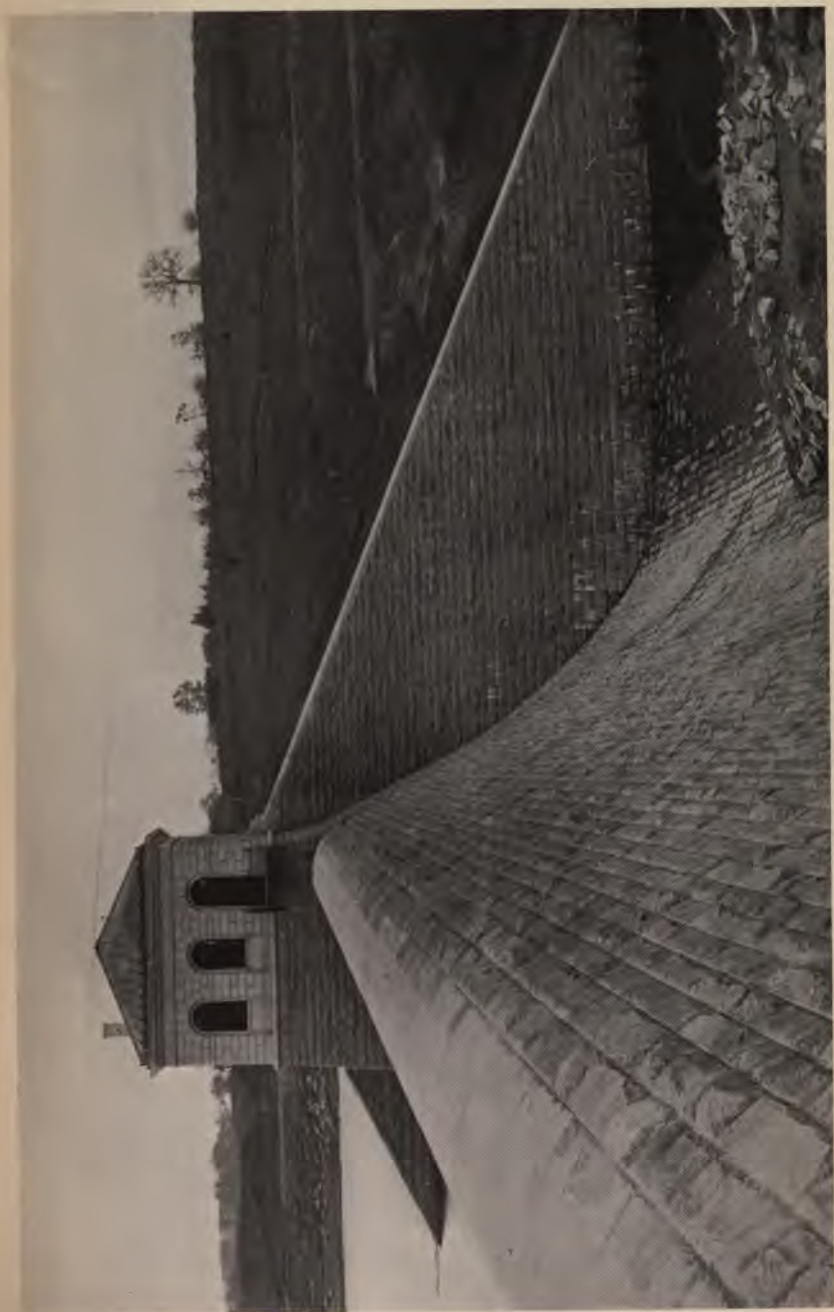
During 1896 the work was prosecuted vigorously, and on December 1, 61 per cent. of the total quantity had been removed. Soon after this date all of the work in the lower portion of the reservoir had been completed, so that it was feasible to begin to store water in it for the purpose of increasing the supply available for the city of Boston.

As already stated, the gates at the dam were closed on Feb. 8, 1897, and were kept closed until the water had risen to a level 16 feet below the top of the spillway. At this elevation of the water the reservoir contained about 1,500,000,000 gallons.

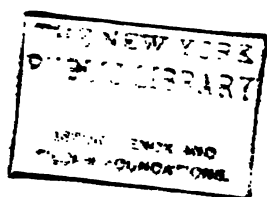
Conditions for Improving the Reservoir.

The work of improving the reservoir was continued during the winter of 1896-97 at a moderate rate, and, as soon as the weather conditions became more favorable in the spring, was prosecuted vigorously.

At the date of the last annual report there were 27 unfinished contracts remaining on this work: at the end of the year 1897, only three contracts remained unfinished, namely, those for sections A, O and Q.



SUDBURY DAM WITH GATE HOUSE AND OVERFLOW — LOWER SIDE.



The following table gives a list of the contractors upon this work, a statement of the work done by them and an approximate estimate of the quantity of material remaining to be removed:—

Progress of Earthwork, Sudbury Reservoir.

CONTRACTOR.	Section.	Total to be moved.	Total moved to Dec. 1, 1896.	Moved Dec. 1, 1896, to Dec. 31, 1897.	Total moved to Dec. 31, 1897.	Remaining to be Moved.
Auguste Saucier, . . .	A	254,096	125,744	115,873	241,617	12,479
Moulton & O'Mahoney, . .	B	215,067	205,000	10,067	215,067	none.
Malone & Strang, . . .	C	355,973	322,000	33,973	355,973	none.
Auguste Saucier, . . .	D	258,996	254,000	4,996	258,996	none.
Charles Linehan, . . .	E	231,737	225,000	6,737	231,737	none.
Newell & Snowling, . . .	F	196,197	194,000	2,197	196,197	none.
Charles Linehan, . . .	G	156,749	150,000	6,749	156,749	none.
Moulton & O'Mahoney, . .	H	176,473	170,000	6,473	176,473	none.
Harry P. Nawn, . . .	I	264,815	169,800	95,015	264,815	none.
Moulton & O'Mahoney, . .	J	182,127	152,400	29,727	182,127	none.
Blagen & Bush, . . .	K	185,629	91,900	93,729	185,629	none.
Moulton & O'Mahoney, . .	L	308,150	126,300	181,850	308,150	none.
Harry P. Nawn, . . .	M	371,430	90,000	281,430	371,430	none.
Thos. Nevins & Son, . . .	N	152,565	130,200	22,365	152,565	none.
Washburn & Washburn, . .	O	485,215	85,000	215,074	300,074	185,141
Harry P. Nawn, . . .	P	325,527	143,000	182,527	325,527	none.
Washburn & Washburn, . .	Q	433,000	143,000	263,657	406,657	26,343
Totals, . . .		4,553,746	2,777,344	1,552,439	4,329,783	223,963

It will be seen, from an examination of the above table, that 1,552,439 cubic yards of earth were moved between Dec. 1, 1896, and Dec. 31, 1897.

Section A.

This section is located at the head of the southerly branch of the reservoir, immediately below the point where the water from the Nashua River will enter the reservoir. The contract for constructing the section was made between the city of Boston and Auguste Saucier, Aug. 27, 1894, and by the terms of the contract the work was to have been completed Dec. 1, 1894, but it is still one of the unfinished sections. The delay in completing the section was caused by legal complications, and not by a lack of diligence on the part of the contractor. These legal complications had prevented work before the contract was assumed by the Metropolitan

Water Board, and continued to prevent work in 1896. On May 20, 1897, work was resumed and prosecuted with diligence during the summer. No work, however, except for one or two days, was done on the Burnett property, lying on the northerly side of the reservoir, until November 23, when an injunction, which had prevented work upon this property to this date, was dissolved by a decision of the supreme court. In the autumn of 1897, as work had been completed upon the portions of the section not affected by the injunction, the contractor was obliged to suspend work. As soon as there was an opportunity to work, however, he began again with a large force, and, notwithstanding the unfavorable season of the year, had advanced so far toward the completion of the section at the end of the year that the portion within the limits of the reservoir will probably be finished before the winter is over.

Sections B to H, inclusive.

These sections represent the contracts made by the city of Boston in 1895. The work upon all of them was far advanced at the end of 1896, and was completed early in 1897.

Sections I to N, inclusive, and Section P.

These sections were constructed under contracts made by the Metropolitan Water Board in 1896, and were, by the terms of the contracts, to be completed on or before Dec. 1, 1897. They were completed from time to time during the year. The dates when these sections were substantially completed were as follows:—

SECTION.	Contractor.	Date.
I.	Harry P. Nawn,	November 27.
J.	Moulton & O'Mahoney,	June 19.
K.	Blagen & Bush,	October 15.
L.	Moulton & O'Mahoney,	November 13.
M.	Harry P. Nawn,	October 23.
N.	Thomas Nevins & Son,	June 26.
P.	Harry P. Nawn,	December 11.

Sections O and Q.

These sections are located at the extreme northerly end of the reservoir, and are being constructed by Washburn & Washburn, contractors. Mention was made in last year's report of the slow progress of the work, and of the fact that, owing to difficulties encountered in the excavation of the soft material to a depth of 10 feet from an extensive swamp, the contractors had been given permission to excavate and convey the materials to the dumping areas by the use of a pumping dredge and pipes.

The dredging scow, with its boilers, engine, pump and other machinery, was completed in the early part of the year, and a sufficient length of pipe, 15 inches in diameter, was provided for conveying the mingled water and mud to the areas to be filled. A portion of these pipes rested upon floats to support them across the water in the dredging basin.

This machinery was put in operation April 14. Late in the year, when the machinery was in good working order and the dredge was operating under favorable conditions, an output of about 100,000 cubic yards in a month was reached; but during a large part of the year the output was small, owing to interruptions required to make the many repairs and alterations which were found to be necessary. At one time there was a long delay in order to make extensive alterations and repairs upon the engine, and after these were made the dredge was used only a short time before it was concluded to substitute a new and larger engine for the one upon the dredge.

In the removal of the material by dredging much care was taken to prevent the dirty water from going into the reservoir, and thus affecting the water supplied to the city of Boston. The area from which the material was dredged was cut off from the rest of the reservoir by small dikes.

The water and mud pumped by the dredge were discharged into large ponds formed upon the areas to be filled by building small dikes around them. These ponds were of sufficient size to give the material in the water an opportunity to settle before the water reached the channel through which it flowed back into the dredging basin.

A portion of the swamp in which Washburn & Washburn were operating was included in the contract of Harry P. Nawn, con-

tractor for Section M. and in the summer Mr. Nawn's force was excavating the mud upon his section by hand, which required that the excavations should be kept free from water. In order to prevent the water in the dredging basin on sections O and Q from flowing upon Section M. Washburn & Washburn were keeping the water slightly below the level of the surface of the swamp, and were leaving unexcavated a strip of swamp 100 feet in width adjacent to Section M.

As there seemed to be some danger that this barrier might prove insufficient in the deeper and softer portions of the swamp, and as the appliances of Mr. Nawn seemed better adapted for excavating near the surface of the swamp, and those of Washburn & Washburn for excavating the material below the surface which was nearly free from roots, an agreement was entered into on July 7, between the Commonwealth and each of these contractors, by which Mr. Nawn was to leave upon his section the lower layers of the swamp, to be excavated by Washburn & Washburn, and to excavate from Section O an equivalent quantity of material to a depth of about 4 feet below the surface of the swamp: this quantity of material amounted to 66,270 cubic yards. Mr. Nawn was, by the terms of his agreement, to complete his work upon the swamp on Section M on or before September 1, and the work on Section O on or before October 8. He did all of the work very expeditiously, completing that on Section M on August 12 and that on Section O on September 16.

The contracts for sections O and Q required their completion on or before Dec. 1, 1897. As it was evident before this date that Washburn & Washburn would fail to have their work completed, or nearly completed, at the date required by the contract, and as it would be necessary to fill the reservoir in the spring of 1898 in order to provide a sufficient water supply for the Metropolitan Water District, it was decided to enter into an agreement with these contractors, whereby, after the Metropolitan Water Board had filled the reservoir in the spring of 1898 and drawn it down later in the year, sufficiently to permit the cutting off of the dredging basin from other portions of the reservoir, the contractors were to resume work upon these sections.

Methods of Excavating employed.

Both the stripping and the shallow-flowage work required, as a rule, the removal of a shallow layer of soil or earth, and frequently the material contained many boulders. The contractors, therefore, found it best to depend almost wholly upon hand labor for excavating, but they used both carts and cars for carrying the material to the areas to be filled. In many swampy places the material beneath the mud was a very fine, wet sand, clay or other material, which would not support either carts or railroad tracks upon ordinary ties. In such places a continuous plank roadway was provided for the carts, and considerable planking was used beneath the ties, in order to support the tracks.

In many cases the cars were hauled from the reservoir up an incline by the use of a stationary hoisting engine, and were then hauled to the place of deposit by horses or a locomotive. The use of inclines and hoisting engines proved in many cases to be both economical and expeditious.

For instance, a single incline and hoisting engine was used by Harry P. Nawn in the removal of the material from the upper portion of the swamp on Section O. In the swamp where the excavation was being made there were two tracks, and while the train on one track was being filled, another train of empty cars was allowed to run down by gravity upon the other track, dragging a wire rope attached to the drum of the hoisting engine. The wire rope was then transferred to the loaded train, which was hauled to the top of the level ground. The same shovellers filled trains on both tracks. The length of the trains varied according to circumstances, but upon this work there were generally from 11 to 16 cars to a train, each car holding from 2 to $2\frac{1}{2}$ cubic yards.

Mr. Nawn in this case succeeded in removing 66,270 cubic yards in 49 working days, which makes an average of 1,352 cubic yards removed daily.

Circular Dam.

This dam, which was built by Holbrook, Cabot & Daly, contractors, is located just west of, and abutting against a road which crosses the southerly arm of the reservoir toward its upper end. It is intended to prevent the drawing down of the water in a portion of the reservoir where the general depth is about 8 feet. The water from the Wachusett Aqueduct will pass over this dam, and,

in order to make the fluctuations of the water level above the dam small, an overfall 150 feet in length was provided.

The dam is built in close connection with the existing masonry of the stone arch under the road. It is founded upon concrete, and consists of rubble masonry, with a split-stone face, surmounted by a dimension stone crest 3 feet in width. The top of the dam is 2 feet below the level of the full reservoir. In the middle of the dam an opening 8 feet wide has been left, to be closed with stop planks. The contract was dated Sept. 2, 1897, and the work was completed November 17, at a cost of \$4,550.27.

Iron Fence.

Work has continued on this contract for building the iron fence along the new roads in Southborough and Marlborough, and the work was completed in November. The total length of fence built under the contract was 22,400 feet, of which 12,510 feet were constructed in 1897. The contractor was Henry Parsons of Marlborough, Mass., and the total amount of the contract was \$17,904.61.

Cost of Improving Reservoir.

The total amount of payments upon contracts for the improvement of the reservoir from Dec. 1, 1896, to Dec. 31, 1897, exclusive of the circular dam and the iron fence, but including all other work upon roads and railroads, has been \$531,393.13.

Force employed on Reservoir.

The largest force employed in 1897 on the improvement of the reservoir was during the week ending July 24, when 792 men and 190 horses were at work.

48-INCH PIPE LINE, DAM NO. 3 TO THE SUDBURY AQUEDUCT.

This line of pipe is in addition to a similar line of pipe laid by the city of Boston when the works were originally built.

Framingham Reservoir No. 3, which is located on Stony Brook, will, in the future, derive the greater part of its supply from the Nashua River, and it is expected that the water in this reservoir will be of much better quality than the water in Framingham Reservoir No. 2, which is supplied by the main Sudbury River. With the additional capacity furnished by the new pipe, the water of the Nashua River, mingled with the water from the Stony Brook branch

of the Sudbury, can be sent directly to the Metropolitan Water District without being mingled with the water from the main Sudbury River.

The pipes were delivered by the pipe makers on the cars in Framingham. A contract for teaming and distributing the pipes was made with L. F. Childs of Framingham. On Sept. 3, 1897, a contract for laying the pipes was made with Harry P. Nawn.

The pipe line, which has a length of 5,518 feet, begins at the gate house at Framingham Reservoir No. 3, crosses the old 48-inch pipe near the gate house, and follows along the northerly margin of Framingham Reservoir No. 1 to Framingham Dam No. 1.

The pipes are laid at a regular inclination, and a large part of the way are below the level of the water in the reservoir. The pipe line crosses Framingham Dam No. 1 near its northerly end, then turns at right angles to its previous course and runs in a southerly direction parallel with the dam, and crosses the river about 2 feet beneath its bed, then rises to join the aqueduct a short distance below the gate-house.

Where the pipe passes through Framingham Dam No. 1 it is in a deep cutting, and below the bottom of the core wall of the dam. An addition to the core wall was carried down under the pipe to a solid foundation, and additional cut-off walls were built around the pipe.

At the connection with the Sudbury Aqueduct a small chamber has been provided, and a 48-inch gate has been placed on the end of the pipe, to control the flow through it. A relief pipe connects with the 48-inch pipe a short distance from the gate, and runs to the gate house, where its open end is carried up slightly above the level of the water surface in Framingham Reservoir No. 3. This is intended to prevent undue strain upon the 48-inch pipe when closing the gate. The pipe for the greater part of its length has a thickness of 1 inch, but where it passes through the dam and below the dam the thickness is $1\frac{1}{4}$ inches.

The laying of the pipe and all incidental work were completed on December 29. The cost of the contract work was as follows:—

Cast-iron pipes and specials,	\$27,175 06
L. F. Childs' contract for distributing pipes,	1,970 95
H. P. Nawn's contract for laying pipes, including chambers and connections at the ends,	15,269 27
Total,	\$44,415 28
Cost per linear foot, \$8.05.	

ROADS.

Considerable work has been done in improving and keeping in repair the roads built in connection with the Sudbury Reservoir.

SANITARY INSPECTION.

The sanitary inspection as outlined in the previous annual report was continued throughout the year. The regulations in regard to the inspection, use and disinfection of latrines have been rigidly enforced. The results have been satisfactory. No epidemics have occurred, and very little sickness has developed among the workmen during the year, and the streams have been protected from contamination.

AMOUNT OF WORK DONE.

The quantity of contract work done in this department from Dec. 1, 1896, to Dec. 31, 1897, is approximately as follows:—

Earth excavation (cubic yards),	1,580,000
Riprap (cubic yards),	3,566
Paving (cubic yards),	3,383
Rubble-stone masonry (cubic yards),	643
Concrete masonry (cubic yards),	451
Split-stone masonry (cubic yards),	384
48-inch pipe laid (linear feet),	5,518

ENGINEERING.

The work of the engineering force has related mainly to the construction of the Sudbury Dam and Reservoir, and the 48-inch pipe line from Framingham Reservoir No. 3 to the Sudbury Aqueduct.

In addition to the above work, however, a small force has been employed for more than half the year in preparing plans of all the water-works lands to be taken from the city of Boston, in accordance with the provisions of the Metropolitan Water Act. Sixty-eight plans were prepared for filing in the different counties, as follows:—

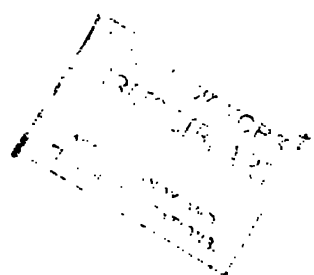
Norfolk County,	9
Middlesex County,	49
Worcester County,	10
Total,	<hr/> 68



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Much work has been done upon a contour map of the Sudbury Reservoir, showing contours one foot apart, which is to serve as a basis for estimating the capacity of the Sudbury Reservoir at different levels.

DISTRIBUTION DEPARTMENT.

DEXTER BRACKETT, *Department Engineer.*

The work in this department comprises the pipes, pumping stations, distributing reservoirs and other works in the Metropolitan District.

During the past year the work of construction has related mainly to the laying of the pipes required to distribute water to the cities and towns in the Metropolitan Water District, and this work is now far advanced toward completion.

Much work has been done in the designing and purchasing of pumping engines, and in the designing of pumping stations and distributing reservoirs.

The organization of the force has been nearly the same as during the previous year, although the increased amount of work has required more engineers.

William E. Foss, John L. Howard and Caleb M. Saville have been during the whole year assistant engineers in charge of surveys and construction. Alfred D. Flinn, in addition to taking charge of the pipe accounts, has been an assistant engineer in charge of surveys and construction since June. Chester J. Wallace is an assistant engineer, engaged on surveys. William B. Fuller was office assistant, in charge of miscellaneous investigations, until July 9, when he resigned to accept a position at Albany, N. Y. Alfred O. Doane has had the general superintendence of the pipe yards, inspection of valves, the testing of pipe lines and the testing of cement. Will J. Sando began work on June 1, as inspector of pumping machinery.

On December 14, a department was organized for the maintenance of the pipe lines, many of which were to be put in operation on Jan. 1, 1898. George E. Wilde was placed in charge of these pipe lines and of the pipe yards, and George A. Lane and Benjamin Myers were appointed as foremen under him.

The engineering force in this department, including inspectors, numbered 31 at the beginning of the year, and was increased from

time to time until it reached a maximum of 67 in the months of October and November. The average number in the force during the year was 53. In addition to the engineering force, 5 foremen and 30 laborers have been employed at the five pipe yards which have been maintained for the storage of pipes.

PIPES.

During the year seven contracts for straight pipes and four contracts for special castings have been made. In addition to the pipes and castings obtained under these contracts, five orders were given for small lots of pipes and castings, for which no formal contract was made. Under these, and contracts uncompleted at the close of the year 1896, 32,198 tons of pipes and 1,464 tons of special castings were received at the pipe yards in 1897.

The system of careful inspection of the pipes and of the iron used in them has been continued, and it is worthy of notice that the character of the iron used in the manufacture of our pipes has been much improved on account of the daily tests made to determine the transverse breaking strength of the iron.

At the beginning of the year there were three pipe yards, but, in order to deliver the pipes at points convenient to the southern part of the Metropolitan Water District, additional pipe yards were established at Brighton on the Boston & Albany Railroad, and at Forest Hills on the New York, New Haven & Hartford Railroad.

In December, the Somerville pipe yard, first established, was given up, and pipes and other material remaining in it were transferred to the yards at Brighton and Edgeworth.

All of the contracts for pipes and special castings are now practically completed, and 13,303 tons of pipes and special castings now stored in the pipe yards will complete nearly all of the pipe lines required to supply with water the cities and towns included in the Metropolitan Water District.

The following table gives the number of tons of pipes and special castings received at the pipe yards from the foundries and used for pipe laying during the years 1896 and 1897:—

	Tons received 1896.	Tons received 1897.	Tons used 1896.	Tons used 1897.	Total received.	Total used.	On Hand.
48-inch,	27,950	15,605	16,435	21,475	43,555	37,910	5,645
42-inch,	25	2,327	-	2,271	2,352	2,271	81
36-inch,	1,732	8,670	-	5,716	10,402	5,716	4,686
30-inch,	1,458	37	490	903	1,495	1,393	102
24-inch,	529	3,159	481	2,315	3,688	2,796	892
20-inch,	2,516	1,893	1,346	2,039	4,409	3,385	1,024
16-inch,	1,230	125	691	594	1,355	1,285	70
14-inch,	-	12	-	-	12	-	12
12-inch,	133	264	9	224	397	233	164
10-inch,	20	-	1	14	20	15	5
8-inch,	15	20	6	13	35	19	16
6-inch,	11	56	11	32	67	43	24
4-inch,	-	30	-	9	30	9	21
Specials,	810	1,464	271	1,272	2,274	1,543	731
Totals,	36,429	33,662	19,741	36,877	70,091	56,618	13,473

VALVES AND OTHER IRON WORK.

During the year 1896, two contracts for furnishing 72 valves, from 12 inches to 36 inches in diameter, were made with J. H. Long. The work on these contracts progressed slowly, and at the date of the last report only 15 valves had been delivered. The work continued to progress slowly in 1897, and it was not until November 5 that the work was completed. The amount of the contracts was \$14,008.

Three additional contracts for furnishing valves have been made during 1897; one with the Kennedy Valve Manufacturing Company, dated February 15, for furnishing 73 valves, from 12 inches to 36 inches in diameter, amounting to \$11,390; one with the Camden Iron Works, dated June 19, for furnishing 54 valves, from 12 inches to 36 inches in diameter, amounting to \$17,900; and one with the Coffin Valve Company, dated October 2, for furnishing 19 valves, from 12 inches to 16 inches in diameter, amounting to \$1,845. Twenty-five valves of smaller sizes have been purchased from the Chapman Valve Company, and seven sluice gates for the Spot Pond gate house and the Chestnut Hill pumping station have been purchased from the Coffin Valve Company.

Three contracts have been made for furnishing the covering

required for valve chambers; one with the Chelmsford Foundry Company, dated January 23, for furnishing 212 sets of cast-iron frames and covers for chambers for small valves, amounting to \$1,108.02; one with the New Jersey Steel and Iron Company, dated January 29, for furnishing 30 sets of steel beams and plates for covering chambers for large valves, amounting to \$1,091.55; and one with the New England Structural Company, dated Oct. 23, 1897, for furnishing 50 sets of steel beams and plates for covering chambers for large valves, amounting to \$1,496.

PIPE LAYING.

The construction of one of the two 48-inch pipe lines, extending from Chestnut Hill Reservoir to Spot Pond, has been pushed forward so that it might be in readiness for use on Jan. 1, 1898, and good progress has also been made on the laying of all of the pipe lines needed for the supply of the several cities and towns in the Metropolitan Water District.

During the past year, 27.7 miles of pipes have been laid, making a total of 42.75 miles. About 10 miles of pipes remain to be laid to complete the system necessary for the supply of all of the cities and towns now included in the Metropolitan Water District, of which 1.1 miles are now under contract.

The work done during the year in connection with the more easterly of the 48-inch pipe lines between Chestnut Hill Reservoir and Spot Pond has been the most difficult and expensive portion of the pipe-line work. It has included carrying the pipes under the Charles, Mystic and Malden rivers, and the crossing under or over the tracks of steam railroads at seven points.

At the terminus of this pipe line at Spot Pond, it has been necessary to construct a gate chamber and an inlet extending 586 feet into the pond. This inlet was constructed of concrete masonry, and its bottom is 16 feet below high water in the pond.

This main pipe line was cleaned and tested before the end of the year, in readiness to be put in use as far as the Malden River on January 1. During the month of January it is expected that the remainder of the line, including the inlet into Spot Pond, will be completed and ready to convey the water from Chestnut Hill Reservoir to the pond. The branch from this pipe extending from Malden through Everett to Chelsea has been laid and is ready for use.

The second 48-inch line from Chestnut Hill Reservoir to Spot Pond will, for the present, be laid only as far as to its junction with the 24-inch and 30-inch mains of the Mystic system. All of this portion of the line has been laid, with the exception of a length of 3,050 feet in North Harvard Street, Brighton, between Franklin Street and the Charles River. The laying of this portion has been delayed on account of a proposed widening of the street.

The main pipes for the northern high-service system are nearly all laid, but cannot be put into general use until the completion of the northern high-service pumping station and reservoir, the construction of which has not yet been commenced.

Good progress has been made upon the work of laying the southern high-service main pipes, which are to extend from the pumping station at Chestnut Hill to Watertown and Belmont on the north and to Quincy on the south. The pipes are laid from the Chestnut Hill station to Watertown, with the exception of a short length where the pipe crosses Charles River.

A contract has been made for laying the pipe from the Chestnut Hill station to Forest Hills in West Roxbury, and the most difficult portion of the work, in the town of Brookline, has been completed.

Very nearly all of the pipes through Milton and in Quincy have been laid. There is a gap between Forest Hills and Milton Lower Mills, for which the pipes have been purchased, but the contracts for laying have not yet been made.

The pipe lines have, for convenience, been divided into sections, and in making the detailed statement of the pipe laying during the year the work will be described by sections, although a section frequently includes the work done by several parties.

Sections 1 to 7 and 9 to 12, inclusive, cover the easterly and westerly 48-inch low-service pipe lines, each about 12 miles in length, extending from Chestnut Hill Reservoir to Spot Pond. The two lines are laid in the same trench from Chestnut Hill Reservoir to Winchester Street in Brookline, and to this street are included in Section 1 and a part of Section 2. The remainder of Section 2, and sections 3 to 7, complete the easterly pipe line to Spot Pond. This line crosses Charles River, near Cottage Farm, and passes through Central Square in Cambridge, Union Square in Somerville and the business section of the city of Malden. Sections 9 to 12 complete

the westerly pipe line to Spot Pond. This line passes through Allston, near the railroad station, Harvard Square in Cambridge, and will pass through the business section of the city of Medford.

Section 8 is a branch from the easterly line, extending from Malden, through Everett to Chelsea, a distance of 2.9 miles.

Sections 13 to 18, inclusive, are northern high-service pipe lines. Section 13 extends from a pumping station at Spot Pond to a reservoir in the Middlesex Fells, thence southerly to the corner of Highland Avenue and Pleasant Street in Malden, where the main line divides into two branches. Sections 14, 15 and 16 include the easterly branch, which extends from Malden, through Everett, Chelsea and Revere to Breed's Island in Boston. Section 17 includes smaller branch lines leading to the Chelsea and Revere reservoirs. Section 18 is the westerly branch, running westerly and then southerly from Malden, through Medford into Somerville.

Sections 19 to 24, inclusive, are southern high-service pipe lines. Sections, 19, 20 and 21 extend from Chestnut Hill Reservoir, through Brookline, Boston and Milton to Quincy. Section 22 is a branch leading from the main line in the Dorchester district of Boston, near the Neponset River, to Hyde Park. Sections 23 and 24 run north-westerly from the reservoir through Newton into Watertown.

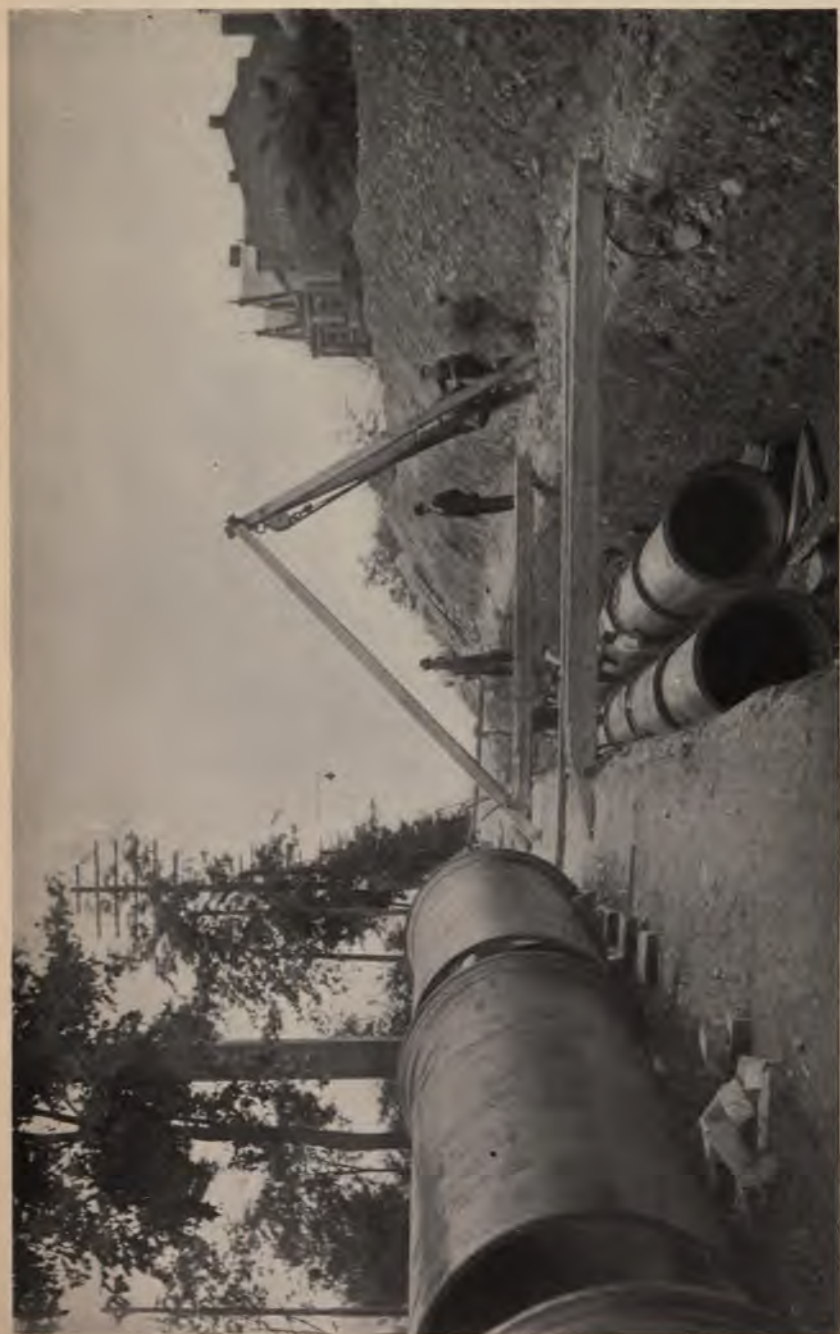
Section 1, — Boston.

Low-service pipe lines in Chestnut Hill Reservoir grounds between pumping station and Chestnut Hill Avenue; double line of 48-inch pipes, each line 1,430 feet in length.

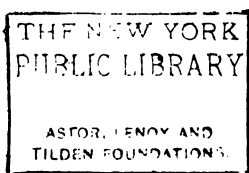
The contract for laying 2,080 feet of the pipes on this section and for making the connection with the high-service mains of the Boston Water Works was made with Malone & McHale. The work was commenced Nov. 1, 1897, and by the terms of the contract was to be completed Dec. 1, 1897. During November the progress made was very unsatisfactory, and soon after December 1 arrangements were made between the contractors and their surety by which H. A. Hanscom & Co. performed a portion of the work. On December 30 the pipe laying was completed and the pipes tested.

The construction of the valve chambers and the refilling and resurfacing of the trenches remain to be done, and some of the work cannot be finished until spring.

Serious difficulties were encountered on this section. The trench was excavated much of the way through filled earth overlying a



DISTRIBUTION SYSTEM — LAYING OF DOUBLE LINE OF 48-INCH PIPES IN BROOKLINE.



swamp, and considerable water was encountered; quicksand was also met with in several places. Beneath 700 feet in length of the pipes the earth was so soft that plank platforms were used to support them, and beneath 265 feet of the platform gravel was deposited to an average depth of six inches.

Where the pipes were laid under the 30-inch and 36-inch high-service mains of the Boston Water Works, steel beams resting on brick piers were used to afford a permanent support for the Boston pipes.

A Venturi meter was set at the connection of the 48-inch pipes with the Boston Water Works mains, for the purpose of measuring the water which it is intended to run through this connection to supply the northern part of the Metropolitan Water District.

Section 2,—Boston and Brookline.

Low-service pipe lines; double line of 48-inch pipes in Beacon Street from Chestnut Hill Avenue in Brighton to Winchester Street in Brookline; then a single line of 48-inch pipes through Beacon and St. Paul streets and across private land to the Boston & Albany Railroad near Charles River; 20,354 feet of 48-inch pipes.

These pipes were laid in 1896 by Curnan & Hochstadter, contractors, but some gaps were necessarily left on account of the delay in furnishing the valves.

The work on this section during the past year has been the placing of these valves and the connections between the two lines of pipe at the corner of Beacon and Winchester streets, the making of a 36-inch connection in Beacon Street near Pleasant Street with the 48-inch main of the Boston Water Works, and the laying of blow-off pipes at several points. The valves were placed and the connections made by E. W. Everson & Co., and the blow-off pipes were put in by Bruno & Salomone.

Section 3,—Easterly Crossing of Charles River.

Low-service pipe line; double line of 36-inch pipes under the Boston & Albany Railroad and across the Charles River, connecting with a single line of 48-inch pipes at either end. This section included 10 feet of 48-inch pipes and 2,031 feet of 36-inch pipes; MacRitchie & Nichol, contractors.

For convenience in construction and to guard against the interruption of the water supply in case of accident, two lines of 36-inch pipes were used instead of a single line of 48-inch pipes for crossing under the railroad and river.

Gates were provided at each end of each of the 36-inch pipes, so that in case of accident to either one the flow could be maintained through the other while the repairs were being made.

The contract was dated Feb. 4, 1897. Dredging for the trench in which the 36-inch pipes were to be laid was begun April 5 and completed April 13. The pile driving for the pipe foundation on the Cambridge shore was commenced April 26 and completed April 30. Pipe laying was begun on the Cambridge shore on April 22; the first section of the submerged pipes was laid on May 11, and the eighteenth and last section was laid on June 15.

A delay of about six days was caused by not receiving the special castings required at the shore end, but on June 24 the excavation under the Boston & Albany Railroad was begun, and on July 6 the pipes under the railroad were all laid and the trench backfilled. On July 12th pipe laying was completed and connections made with the pipes already laid at either end of this section.

The 36-inch pipes used for the portion of this work which is in the river are 1.65 inches in thickness and weigh 677 pounds per linear foot.

Three types of joints were used. The first differed from the ordinary pipe joint by substituting three turned grooves in the bell for the usual single groove. These grooves were for the purpose of holding the lead more securely. In the second type the bell was the same as in the first, but the spigot was smoothly turned with a straight taper to a standard pattern, so as to be interchangeable. After inserting one of these tapering spigots in the bell of a pipe, and running the joint with lead, the spigot could be withdrawn, and when again inserted would make a tight joint. The third type was a flexible ball-and-socket joint. The spigot end of the pipe was made larger and thicker than in ordinary pipes, and turned truly spherical. On the inner surface of the bell, 8 inches in from the end, there is a raised ring 1 inch in width, which is turned to fit the spherical surface of the spigot end. In the bell between this ring and the end of the pipe there are five grooves to hold the lead, of which about 280 pounds were used for each joint. This joint permitted a deflection of about one in ten, and was designed so that the whole deflection could take place without having any portion of the spigot end project into the waterway.

A trench about 25 feet wide at the bottom, and averaging 8 feet

in depth, was dredged across the river, and, where left uneven by the dredge, the bottom was smoothed by means of a wooden plow, which was attached to a large flat-bottomed boat and drawn along the trench by a rope leading to an engine on the pipe-laying scow.

The pipes were put together on a platform on the shore in sections, consisting generally of six pipes. At one end was the turned taper spigot, and at the other end, the bell in which lead had been cast to receive one of these spigots.

The pipe-laying scow was rigged with two derricks, from which a stiff truss about 75 feet in length was suspended in such a manner that the section of pipes fastened to the truss would hang just clear of and parallel with the side of the scow. By means of mooring lines running in different directions, and controlled by winches on the scow, the scow could be readily moved either a large or a very small distance, so as to get the line of pipes exactly upon the line and location where they were to be placed. They were then lowered, and by slight movements vertically or sideways, as directed by the diver, were brought into the proper position, so that the taper spigot at the end of the section would enter the leaded bell of the section previously laid. To assist in this operation, and to protect the lead in the bell from injury, a wrought-iron guide ring was attached to the bell of each section before lowering. As soon as the taper spigot was entered in the guide ring, a hook on the end of the piston rod of a hydraulic cylinder attached to the truss was fastened to a chain attached to the section of pipe already laid, and, by pumping water into the cylinder through pipes leading from the scow, the two sections of pipe were drawn together with much force. The joints were afterward calked by the diver.

Where there were vertical deflections in the pipe, and where it was thought there might be movement from future settlement, one or more flexible joints were used in a section.

Section 4, — Cambridge and Somerville.

Low-service pipe line from Charles River, through Magazine Street, Massachusetts Avenue and Norfolk Street in Cambridge, and Webster Avenue, Union Square, Bow Street, Walnut Street, Chauncey Avenue and the Middlesex Fells Parkway in Somerville to the Mystic River; 19,053 feet of 48-inch pipes.

A contract for laying 15,884 feet of this pipe line between the Charles River in Cambridge and Broadway in Somerville was made with Snyder & Williams on Aug. 6, 1896, and they laid 9,593 feet

of this line during the year 1896. The contractors resumed work on April 5, 1897, and completed the pipe laying on June 19 and the entire work on July 3.

The pipes for the remainder of the distance to the Mystic River were laid by C. A. & C. E. Trumbull, under a contract dated April 2, 1897. They began work on April 13 and continued at work until June 19, when it was necessary to suspend work until the new Metropolitan Parkway, through which the pipes were to be laid, was excavated to grade. Work was resumed on October 11 and completed December 10.

These contractors laid 2,920 feet of 48-inch pipes, of which 890 feet required a pile foundation.

The work done by Snyder & Williams was quite difficult. In Webster Avenue the pipes were laid under the tracks of the West End Street Railway for a distance of 1,650 feet, necessitating the removal and relaying of tracks. In connection with the laying of 6,291 feet of 48-inch pipes in 1897, it was necessary to relay 3,670 feet of gas pipes from 3 inches to 12 inches in diameter, in order to get them out of the way of the large pipes, and to lay 531 feet of 12-inch sewer pipe to provide for house drainage cut off by the large pipes.

At the crossing of the Boston & Maine Railroad the 48-inch pipes were carried above the tracks on a plate girder bridge, which was erected by the Boston Bridge Works at a cost of \$2,497.

Gaps were left in the 48-inch pipe line at the junction of Pearl and Walnut streets, and at Broadway, to await the making of connections with the 30-inch and 24-inch supply mains of the Boston Water Works. These gaps were filled and the connections were made by E. W. Everson & Co.

At Webster Avenue a connection was made with the Somerville pipes. Branches have been placed where they will be available for future connections in Cambridge, at the corner of Magazine and Pearl streets, at Central Square, and at the corner of Norfolk and Cambridge streets.

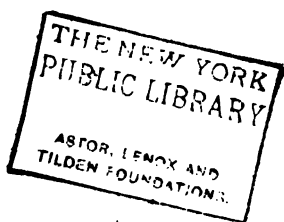
Section 5,—Easterly Crossing of Mystic River.

Low-service pipe line; double line of 36-inch pipes across the Mystic River, connecting with a single line of 48-inch pipes at either end; 116 feet 48-inch pipes, 2,636 feet 36-inch pipes; MacRitchie & Nichol, contractors.

The pipes were laid across this river in the same manner as across the Charles River, except that, on account of the mud in



DISTRIBUTION SYSTEM — LAYING OF SUBMERGED PIPES ACROSS MYSTIC RIVER.



the bottom of the river, which was from 10 to 15 feet in depth, the pipes were all laid upon a pile foundation. A view of the work upon this section, taken from the easterly side of the river, may be found opposite page 84.

Spruce piles were driven in bents 12 feet apart, and capped with 10-inch by 10-inch spruce, 10 feet in length.

For a distance of 100 feet at the channel the tops of the pipes are 9.6 feet below Boston city base (about 10 feet below mean low water), rising gradually on either side of the channel. For the greater part of the distance across the river the tops of the pipes are at mean low water. Five of the flexible joints were used on each line. The pipes were laid in the same general manner as at the crossing of the Charles River.

Section 6,—Medford and Malden.

Low-service pipe line; single line of 48-inch pipes from the Mystic River, through Middlesex Avenue and Medford Street to the Malden River; a double line of 36-inch pipes under the Malden River, and single line of 48-inch pipes in Medford, Green and Jackson streets and through private land to Pleasant Street in Malden; 11,638 feet of 48-inch pipes, 498 feet of 36-inch pipes.

In 1896, D. F. O'Connell laid the first 6,700 feet of this line from the Mystic River to the corner of Medford and Pearl streets in Malden.

On April 2, 1897, a contract for laying 4,926 feet of 48-inch pipes, on this section, in connection with other pipes to be laid on Section 8, was made with the C. H. Eglee Company. Most of this work was completed on October 9, but on account of delay in receiving valves and special castings, the contract was not completed until December 18.

This contract included some difficult work, as the pipes were laid under the tracks of the Boston & Maine Railroad at three points and under the channels of the Saugus Branch and Spot Pond brooks.

On Oct. 5, 1897, a contract for laying the 36-inch pipes under the Malden River was made with Moore & Co. and Wm. H. Ward. As at the crossings of the Charles and Mystic rivers, a double line of 36-inch pipes was laid beneath the bed of the river, but the method of laying the pipes was radically different. Owing to the fact that this river is shallow,—its bottom being approximately at the level of low tide,—and that there is very little navigation past this point, it was decided to lay the pipes inside of a coffer-dam. In constructing the coffer-dam, 6-inch tongued and grooved spruce

planks, about 24 feet long, were driven through the mud and an underlying sand stratum into a stiff clay. Within the two lines of sheeting, which were about 15 feet apart, the earth was excavated, the water was pumped out, and the pipes were laid in the usual manner for open trench work.

For a distance of about 94 feet under the river the pipes are laid level, with their tops 5 feet below Boston city base and about $5\frac{1}{2}$ feet below the river bed.

The level portion of the pipes rests upon a foundation of stiff clay, but on the slopes on either side piles have been driven for supporting the pipes and the valve chambers. In order to lay the pipes, portions of the bridge pier, fender guard and granite sea wall had to be removed and rebuilt.

The work was begun October 13, and at the end of the year the pipes had nearly all been laid, connections had been made on the west shore, and the work was progressing in such a way that it was expected that the connections on the east shore would be made by the middle of January.

On this section connections have been made with the Medford water pipes at the corner of Middlesex Avenue and Second Street, and with the Malden water pipes at Medford Street, corner of Pearl Street, Medford Street, corner of Green Street, and Jackson Street, corner of Charles Street.

Section 7, — Malden, Melrose and Stoneham.

Low-service pipe line, through Pleasant and Washington streets, Ravine Road and private property to Spot Pond; 14,317 feet of 48-inch pipes. All of this pipe line was laid by the C. H. Eglee Company, and nearly all under two contracts, one made in 1896 and the other Oct. 13, 1897.

About 11,233 feet of this line were laid in 1896, but, owing to delay in the delivery of the pipes, a portion of the work called for by the contract made in 1896 was not done until 1897. Work under this contract was resumed on April 9, in Washington Street, Malden, near Lyle Street, and completed May 15 in Washington Street, near Clifton Street. As the pipes were being laid, a gap was left at the crossing of the Boston & Maine Railroad, on account of contemplated changes in the bridge over the railroad at this place.

On June 30, 1897, an agreement was made with the Boston & Maine Railroad by which the Metropolitan Water Board was granted

the right to lay the pipes across and under the railroad, near the bridge, thus avoiding the necessity of constructing a bridge for the support of the pipes over the tracks, as well as the trouble which might arise if the contemplated changes in the bridge should be made.

The work of closing this gap was done by the C. H. Eglee Company, under an agreement dated September 22. The work was completed on October 20.

Four hundred and fifty feet of this 48-inch pipe line nearest Spot Pond were laid by the C. H. Eglee Company in 1897, under Contract No. 89, which also provided for building the gate chamber near Spot Pond and the inlet works at the pond.

On this section connections were made with the pipes of the Malden Water Works at the corner of Washington and Clifton streets, and at the corner of Washington and Winter streets; also with the pipes of the Melrose Water Works at a point opposite the way leading to the Melrose Reservoir. A branch was put in at the corner of Washington and Pleasant streets, Melrose, for future use.

Section 8, — Malden, Everett and Chelsea.

Low-service pipe line; a branch from the main line starting from the junction of Medford and Bell Rock streets, Malden, and running through Bell Rock Street in Malden, Wyllis Avenue, Main Street, Forest Avenue, Norwood, Corey and Second streets in Everett, and Second Street and Broadway in Chelsea, to the corner of Williams Street; 7,174 feet of 48-inch pipes, 8,062 feet of 42-inch pipes; the C. H. Eglee Company, contractor.

This branch will furnish the low-service supply for the cities of Everett and Chelsea and for East Boston. It will also supply water through existing mains to Charlestown and the north end of Boston. The pipes are 48 inches in diameter as far as Broadway in Everett, and are then reduced to 42 inches.

The contract for the whole of this section and a portion of Section 6 was made with the C. H. Eglee Company, April 2, 1897. The work was commenced on April 13 and completed December 18.

Through Second Street the work was difficult and expensive. A pile foundation was required for a length of 3,350 feet. It was necessary to lay 3,516 feet of 8-inch, 10-inch and 12-inch sewer pipes, to provide for house drainage, and to relay 1,060 feet of gas pipe.

Where Second Street crosses the marsh there is a large culvert, through the top of which the pipes pass. This was taken down and

rebuilt with greater width, upon a pile foundation. The pipes at this culvert are near the surface of the street and are protected from the street travel by an iron shield.

A branch and valve were set at the corner of Main Street and Wyllis Avenue in Malden, but the connection with the Malden pipes has not yet been made. Connections were made with the Everett pipes at the corner of Broadway and Corey Street, with the Everett and Chelsea pipes at the line between Everett and Chelsea, with the Chelsea pipes at the corner of Second Street and Broadway, and with the main pipe which leads from Boston to East Boston at the corner of Broadway and Williams Street in Chelsea.

Section 9, — Brookline and Brighton.

Low-service pipe line; from Beacon Street, through Winchester, Fuller and Harvard streets in Brookline, and Harvard Avenue, Franklin and North Harvard streets in Brighton, to the Charles River; 11,964 feet of 48-inch pipes.

A contract for laying 8,914 feet of this pipe line was made with E. W. Everson & Co. on June 28. The laying of the line through the remainder of the section has been delayed to await a proposed widening of North Harvard Street. The work was commenced July 13 and pipe laying was finished on November 10, but the whole work was not completed until December 11.

In order to provide for the house drainage cut off by the 48-inch pipes, 1,500 feet of 12-inch sewer pipes were laid and 2,120 feet were relaid; 1,575 feet of gas pipes were also relaid.

On account of the small depth of earth over the culvert across Harvard Avenue, near Commonwealth Avenue, the lower part of the pipe passed through the upper part of the culvert. In order to diminish the obstruction, the size of the pipe was reduced to 36 inches, and the culvert was widened to compensate for the reduction in area caused by the pipe.

A branch and valve were set at the corner of Brighton Avenue and Harvard Avenue, but the connection with the Boston pipes has not yet been made.

Section 10, — Westerly Crossing of Charles River.

Low-service pipe line; double line of 36-inch pipes under the Charles River between Brighton and Cambridge, connecting with a single line of 48-inch pipes at either end; 141 feet of 48-inch pipes; 795 feet of 36-inch pipes; MacRitchie & Nichol, contractors.

The work of taking down the river wall and removing the bridge pier was begun October 6. Dredging for the trench was begun

October 11 and finished October 18. The first section of the submerged pipes was laid October 28 and the last section November 20. Pipe laying was completed and connection made with Section 11 on December 14.

The draw pier has been rebuilt and the pipes partially tested, but the contractors decided to leave the completion of the work until next season, and all work was stopped on December 31.

The pipes on this section were laid in the same manner as those on sections 3 and 5, but, on account of the narrowness of the river, more flexible joints were used than at the other crossings.

Section 11,— Cambridge, Somerville and Medford.

From the Charles River in Cambridge, through Boylston Street, Massachusetts Avenue and Beach Street in Cambridge, Willow Avenue in Somerville and Boston Avenue in Medford, to the 24-inch and 30-inch main pipes of the Boston Water Works at College Avenue; 15,097 feet of 48-inch pipes.

Two thousand and forty-one feet of this line nearest Charles River were laid by Snyder & Williams in 1896.

On April 6, 1897, a contract was made with H. A. Hanscom & Co. for the remainder of the section. The work was commenced in Massachusetts Avenue, opposite Church Street in Cambridge, on April 19, and on April 29 work was also begun on Willow Avenue in Somerville. The whole work was completed on Oct. 2, 1897.

In order to avoid interference with the sewers and house drains, the 48-inch pipes in Massachusetts Avenue, from a point about 100 feet south of Jarvis Street to a point near the Fitchburg Railroad, a distance of 3,300 feet, were laid in a trench averaging 13 feet in depth.

Between Kirkland and Waterhouse streets the pipes were laid in Cambridge Common, in order to avoid crossing, in Massachusetts Avenue, the large mains of the Cambridge Water Works.

Where the pipe line passes over the Fitchburg Railroad there was already a pipe bridge to support pipes of the Cambridge Water Works and the Cambridge Gas Light Company. As the highway bridge is likely to be rebuilt and lengthened within a few years, requiring a similar change in the pipe bridge, it was thought best, as a temporary expedient, to lay a 24-inch pipe instead of a 48-inch pipe over the railroad. The pipe bridge was rebuilt so that it would support all three pipes.

In Boston Avenue, Medford, between Harvard Street and College

Avenue, the plans provide for a 16-inch high-service pipe, as well as the 48-inch low-service pipe. Both of these pipes were laid in the same trench.

Connections were made with the pipes of the Somerville Water Works at the corner of Willow Avenue and Elm Street and at the corner of Willow Avenue and Broadway. Branches were set for connecting with the 30-inch and 24-inch main pipes of the Boston Water Works at College Avenue, but the connections have not yet been made. Branches were also placed at two points in Cambridge where they will be available for future use.

Section 12, — Medford.

This section includes the continuation of the 48-inch pipe line from College Avenue, Medford, to Spot Pond. It is proposed to defer laying the pipes for a few years, as the single line to Spot Pond will meet present requirements. It was necessary, however, to construct a bridge to support the high-service pipe crossing the Mystic River; and, as the low-service 48-inch pipe will cross the river at the same place, a bridge was constructed which would support both. In order to avoid disturbing the bridge and the property in its vicinity in the future, 439 feet of the 48-inch pipes are being laid by Cheney & Trumbulls, in connection with work on Section 18.

Section 13, — Stoneham, Melrose and Malden.

Northern high-service pipe line from proposed pumping station at Spot Pond, through Ravine Road and the Middlesex Fells Reservation to the proposed reservoir in the Reservation; thence through the Reservation, the Middlesex Fells Parkway and Highland Avenue, to Elm Street near Pleasant Street in Malden; 11,250 feet of 36-inch pipes; A. W. Bryne Construction Company, contractor.

The contract was dated May 13, 1897. Work commenced in the Fells Parkway, near Highland Avenue, May 20. In the Parkway and through the Reservation a large amount of rock was excavated from the trench. The surplus material from a portion of the work was used to reconstruct the roadway in the Reservation, from the southerly entrance to and through the Jerry Jingle Notch, a distance of about 1,400 feet.

For a distance of about 700 feet south from the proposed reservoir a 16-inch cast-iron pipe was laid in the trench with the 36-inch pipe, to be used as a drain from the reservoir and gate chamber.

A connection with the Melrose water pipes was made on Ravine Road, and one with the Malden water pipes at the corner of Highland Avenue and Clifton Street.

Section 14, — Malden.

Northern high-service pipe line from Highland Avenue, at the corner of Elm Street, through Pleasant, Main and Cross streets to Harvard Street; 7,267 feet of 30-inch pipes; Collins & Ham, contractors.

About one-third of the pipes on this section were laid in 1896. Work was resumed March 29, 1897, and completed July 28.

In both Pleasant and Main streets the pipes were laid close beside the tracks of the West End Street Railway Company. The frequent passing of the cars on these tracks delayed the work of pipe laying, and the progress of the work was also delayed on account of gas, water and drain pipes, which it was necessary to remove before the large pipes could be laid. About 145 feet of water pipes, 2,380 feet of gas pipes and 50 feet of drain pipes were relaid.

A connection was made with the Malden pipes at the corner of Cross and Hancock streets. A branch was placed at Malden Square for future use.

Section 15, — Malden, Everett, Chelsea and Revere.

Northern high-service pipe-line from Harvard Street, Malden, through Hancock Street in Malden; Hancock, High, Foster, Arlington and Nichols streets in Everett; Nichols Street, Washington Avenue and Fenno Street in Chelsea; and Fenno Street, Revere, to a point opposite the Revere Reservoir; 4,192 feet of 24-inch pipes; 9,013 feet of 20-inch pipes; J. H. McKnight, contractor.

This pipe line is reduced from 24 inches to 20 inches in diameter at Broadway in Everett. The work was completed in 1896, with the exception of about 800 feet of line, which were not laid on account of the lack of valves and specials. The work was resumed and completed by Mr. McKnight in August, 1897.

Connections have been made with the Everett pipes at the corner of Broadway and Hancock Street, and at the corner of Nichols and Woodlawn streets, and a branch was placed at the corner of Hancock and Belmont streets for a future connection with the Malden and Everett pipes.

Section 16, — Revere and Breed's Island, Boston.

Northern high-service pipe line from end of Section 15, through Fenno and Beach streets and Winthrop and Atlantic avenues, Revere, and Beachmont and Orient avenues, Boston, to the stand-pipe of the Boston Water Works on Breed's Island; 10,093 feet of 16-inch pipes; 6,063 feet of 12-inch pipes.

This pipe line is reduced from 16 inches to 12 inches in diameter at the corner of Winthrop and Atlantic avenues. A contract for laying the 16-inch pipes was made with George Goodhue, in 1896,

and very nearly completed in that year. Work was resumed on March 29, 1897, and completed on April 14.

Connections were made with the pipes of the Revere Water Company at the corner of Beach and Pleasant streets and at the corner of Winthrop and Atlantic avenues.

At the request of the Massachusetts Highway Commission, which was about to build a State road over a portion of Atlantic Avenue, and consequently desired that the pipe should be laid before the road was built, arrangements were made with H. A. Hanscom & Co. for laying 1,827 feet of 12-inch pipe from Winthrop Avenue to the Boston line. This work was done between Nov. 24 and Dec. 4, 1897.

Section 17,—Chelsea and Revere.

Northern high-service pipe lines; 2,684 feet of 16-inch pipes; 1,122 feet of 12-inch pipes; H. A. Hanscom & Co., contractors.

These lines are branches from the main pipe line in Chelsea and Revere, leading respectively to the Chelsea and Revere reservoirs. The branch in Chelsea runs from Washington Avenue, through Murray Street, Summit Avenue and land of the city of Chelsea, and joins the main pipe leading into the Chelsea Reservoir, which is located on Powder Horn Hill. The branch in Revere runs from Fenno Street, across private land to the Revere Reservoir, and joins the main pipe leading into the Revere Reservoir.

The work of laying these branches was commenced on October 20 and completed December 9.

Section 18,—Malden, Medford and Somerville.

Northern high-service pipe line, from Highland Avenue in Malden through Elm and Pleasant streets in Malden; Salem Street, Middlesex Fells Parkway, Valley, Forest and High streets, across the Mystic River, through South Street Court, South, Walnut and Summer streets, College and Boston Avenues and Harvard and Winchester streets in Medford, and Broadway in Somerville, to Cedar Street; 15,200 feet of 20-inch pipes; 4,370 feet of 16-inch pipes.

This pipe line is reduced from 20 inches to 16 inches in diameter at the corner of College and Boston avenues.

A contract for laying 14,000 feet of the 20-inch pipes was made with Collins & Ham on Oct. 8, 1896, and 4,400 feet of the pipes were laid during that year. Work on this contract was resumed on March 30, 1897, and on July 3 the pipe laying was completed.

In Boston Avenue and Harvard and Winchester streets, 4,294 feet of 16-inch pipes were laid by H. A. Hanscom & Co., in connection with their contract for Section 11.

At the crossing of the Mystic River, in Medford, a steel plate girder bridge 10 feet wide and 78 feet in length, supported by granite masonry abutments, has been built for carrying the 48-inch low-service and 20-inch high-service pipes. The abutments have been built under a contract with Cheney & Trumbulls, dated Sept. 17, 1897.

A steel bridge is being erected by the New Jersey Steel and Iron Company, under a contract dated Sept. 23, 1897.

The 20-inch pipes over the bridge and through private property, connecting on either side with the pipes laid by Collins & Ham, are being laid by Cheney & Trumbulls. Four hundred and thirty-four feet had been laid at the end of the year, out of a total of 636 feet.

Connections with the Medford pipes have been made at the corner of the Fells Parkway and Fulton Street and at the corner of High Street and Governor's Avenue. Branches were also placed at the corner of Pleasant and Murray streets in Malden, and at the junction of the Fells Parkway and Fells Avenue and on Boston Avenue at Professors' Row in Medford.

Section 19, — Brookline and Boston.

Southern high-service pipe line; from the Chestnut Hill pumping station, through Reservoir Lane, Boylston Street, Boston Water Works grounds, Dudley, Warren and Cottage streets in Brookline, and the Parkman Drive and the Arborway in West Roxbury, to South Street, near the Forest Hills station on the New York, New Haven & Hartford Railroad; 18,265 feet of 48-inch pipes.

A contract for all of this work, with the exception of the portion in Reservoir Lane, was made with E. W. Everson & Co., August 3. Work was commenced August 25 and continued until December 28. About 10,184 feet of the pipe have been laid, and the work done comprises the most difficult portion of the contract. Through Warren and Cottage streets, Brookline, the streets are very narrow, at several points not more than 30 feet in width. There is a 30-inch Boston Water Works pipe, as well as gas and water pipes of the town of Brookline, in these streets, and for a large part of the distance the trench had to be excavated in rock. The Boston pipe was shut off, to avoid damage in case it should be broken by the blasting. Two breaks were caused by the work, one of which occurred when the water was let into the pipe on December 28, and caused considerable damage to adjacent property.

Section 20, — Boston.

Southern high-service pipe line from South Street in West Roxbury, through the Arborway and Morton Street in West Roxbury and Dorchester, to River Street; 17,352 feet of 36-inch pipes.

No pipes have been laid upon this section, but the plans have been completed, and a contract for pipe laying will be made early in the coming season.

Section 21, — Boston, Milton and Quincy.

Southern high-service pipe line from the corner of Morton and River streets in Dorchester, through River Street, across the Neponset River, through Adams Street in Milton and Quincy, and Beale Street and Summit Avenue in Quincy, to the site of the proposed reservoir and stand-pipe on Forbes Hill; 15,550 feet of 24-inch pipes; Saucier & O'Brien, contractors.

The contract was dated Sept. 2, 1897. Work was begun September 13, and the pipe laying was continued until November 29, when it was stopped for the season. The work remaining to be done comprises the laying of about 600 feet of pipe, including the portions across the Neponset River and over the New York, New Haven & Hartford Railroad, also the closing of some short gaps where connections are to be made.

Section 22, — Boston and Hyde Park.

This section consists of the branch which leaves the main pipe leading to Quincy at the corner of Morton and River streets in Dorchester, and runs to Hyde Park. No work has yet been done upon it, and the plans have not been completed.

Section 23, — Boston and Newton.

Southern high-service pipe line from the Chestnut Hill pumping station, through Beacon, Hammond and South streets, Commonwealth Avenue and Ward Street to the old distributing reservoir of the Newton Water Works; 7,970 feet of 36-inch pipes; Brano & Salomone, contractors.

The contract was dated Aug. 5, 1897. Work was commenced on August 12 and pipe laying completed on October 28. The whole of this pipe has been laid, with the exception of short lengths where connections are to be made at the pumping station and reservoir.

Section 24,—Newton and Watertown.

Southern high-service pipe line from the Newton Reservoir, through Ward Street, Waverley Avenue, Washington and St. James streets in Newton across private land and the Charles River to Watertown, and through Irving and Mount Auburn streets in Watertown to Palfrey Street; 13,010 feet of 20-inch pipes.

A contract for laying 11,400 feet of these pipes was made with S. W. Frescoln on Sept. 2, 1897. Work was commenced September 20, and on December 8, when the contractor stopped work, all of the pipes had been laid except those at the crossing of the Boston & Albany Railroad in St. James Street, where the bridge was not completed, and at the connection of Mount Auburn and Palfrey streets, where the connections with the pipes of the Watertown supply remain to be laid.

A section through private land and across the Charles River was not included in this contract, mainly because authority had not been obtained from the Harbor and Land Commissioners and the United States government.

A contract for a plate girder bridge of 87 feet span, for carrying these pipes over the Boston & Albany Railroad, was made with the Boston Bridge Works on October 23, and the bridge will be placed in position early in January.

Statistics of Pipe Laying.

*Principal Items of Work done on Contracts for Pipe Laying, to
Dec. 31, 1897.*

	Work done in 1896.	Work done in 1897.	Total to Dec. 31, 1897.
48-inch pipe laid (feet),	49,886	59,446	109,332
42-inch pipe laid (feet),	—	8,075	8,075
36-inch pipe laid (feet),	—	24,396	24,396
30-inch pipe laid (feet),	2,670	4,777	7,447
24-inch pipe laid (feet),	4,204	15,471	19,675
20-inch pipe laid (feet),	13,424	22,469	35,893
16-inch pipe laid (feet),	9,138	8,224	17,362
12-inch pipe laid (feet),	—	3,284	3,284
Rock excavation (cubic yards),	2,640	8,523	11,162
Earth below grade (cubic yards),	1,247	2,726	3,972
Valve chambers built,	44	281	325
Concrete masonry (cubic yards),	163	604	767
Piles driven,	514	1,968	2,482
15-inch sewer pipe laid (feet),	33	—	33
12-inch sewer pipe laid (feet),	1,294	2,706	4,000
10-inch sewer pipe laid (feet),	1,207	1,760	2,967
8-inch sewer pipe laid (feet),	1,086	1,085	2,171
Sewer man-holes built,	20	40	60

Table showing Length of Main Lines and Connections, and Number of Valves set in Same.

	DIAMETER OF PIPES IN INCHES.												Total.
	48.	42.	36.	30.	24.	20.	16.	14.	12.	10.	8.	6.	
Length laid to Jan. 1, 1897 (feet),.	49,886	-	-	2,670	4,204	13,424	9,138	-	-	-	-	-	79,322
Gate valves in same, .	-	-	3	-	-	-	3	-	-	-	-	-	6
Air valves in same, .	17	-	15	-	-	6	4	-	-	-	-	-	42
Length laid during 1897 (feet), .	59,446	8,075	24,396	4,777	15,471	22,469	8,224	3,284	190	28	18	146,381	
Gate valves in same, .	-	-	32	9	12	14	15	-	10	-	-	1	93
Air valves in same, .	89	3	-	3	7	14	4	-	2	-	-	-	72
Length laid to Jan. 1, 1898 (feet),.	109,332	8,075	24,396	7,447	19,675	35,893	17,362	3,284	190	28	18	225,703*	
Gate valves in same, .	-	-	35	9	12	14	18	-	10	-	-	1	99
Air valves in same, .	56	3	15	3	7	20	8	-	2	-	-	-	114

* 42.75 miles.

Statement of Cast-iron Blow-off and Drain Pipes laid to Jan. 1, 1898.

	DIAMETER OF PIPES IN INCHES.					Total.
	16.	12.	8.	6.	4.	
Length laid to Jan. 1, 1897 (feet), . . .	36.0	-	-	22	-	58
Length laid during 1897 (feet), . . .	1,775.6	1,185.4	24	548	339	3,872
Length laid to Jan. 1, 1898 (feet), . . .	1,811.6	1,185.4	24	570	339	3,930
Valves set to Jan. 1, 1897,	1	-	-	1	3	5
Valves set during 1897,	13	34	-	21	5	73
Valves set to Jan. 1, 1898,	14	34	-	22	8	78

SPOT POND.

This pond is to serve as a low-service reservoir for the Metropolitan Water District. The only work of construction during the year has been that incidental to the construction of a gate chamber and inlet, where the water, pumped from Chestnut Hill Reservoir through a 48-inch pipe, enters the pond.

The inlet works include a small portion of the pipe laying on Section 7, and were constructed by the C. H. Eglee company, under a contract dated October 13. This work was one of considerable difficulty, and had to be constructed very rapidly, in order to complete the connection with the pond as soon as possible.

The gate chamber is constructed of concrete, with a granite floor, and contains four compartments, with valves for controlling the flow of water into and from the pond, and also to the proposed northern high-service pumping station, which is to be located near this gate chamber. The floor of the gate chamber is about 12 feet higher than the present high-water level of the pond, so as to provide for the future raising of the pond. The gate chamber has been covered with a temporary wooden building.

Two connections were made from the gate chamber to the pond; the higher one a short connection, made by a 48-inch pipe running to the edge of the pond near the gate chamber, and with its bottom about 4 feet below the present high-water level in the pond; the other a long connection, running out to deep water, with its bottom 16 feet below the present high-water level.

The longer and lower connection consists of a conduit of horse-shoe section, 5 feet high and $4\frac{1}{2}$ feet wide, built of Portland cement concrete. The construction of this conduit had been deferred until the autumn, so that the pond would be at a lower level than earlier in the year. The water was low enough at the time construction was begun to permit cutting off, by a coffer-dam about 400 feet long and a low earth dam 350 feet long, an area of about $4\frac{1}{2}$ acres, which was easily pumped dry.

The work of pipe laying and constructing the gate chamber and the part of the conduit near the shore progressed very expeditiously; but the construction of the conduit from a point a short distance from the shore out to the end proved to be very difficult, on account of the soft mud and quicksands encountered. The work was, however, progressing well at the end of the year, with the probability that the conduit would be completed in about two weeks.

NORTHERN HIGH-SERVICE PUMPING STATION AND RESERVOIR.

Land for the site of the northern high-service pumping station on the easterly shore of Spot Pond, just south of the outlet of the pond, has been purchased, and it is intended to move to a pumping station located on this site one of the pumping engines in the Mystic pumping station. Considerable work of a preliminary nature has been done in connection with this station, but the final plans have not yet been prepared.

The site of the high-service distributing reservoir in the Middlesex Fells has been cleared of wood, but no contracts for constructing the reservoir have been left. Plans for the work are now being prepared. A view of a portion of the site of this reservoir may be seen on the opposite page.

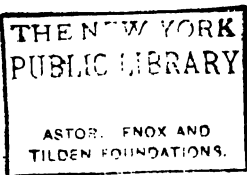
CHESTNUT HILL HIGH-SERVICE PUMPING STATION.

On Jan. 1, 1897, a contract was made with the E. P. Allis Company of Milwaukee, Wis., for building a pumping engine having a daily capacity of 30,000,000 gallons, to be erected in the extension of the existing Chestnut Hill pumping station; and on September 21 a contract was made with C. A. Dodge & Co. for building, from plans prepared by Wheelwright & Haven, architects, the extension of the engine house.

The E. P. Allis Company has made good progress in the con-



DISTRIBUTION SYSTEM—SITE OF NORTHERN HIGH SERVICE RESERVOIR IN MIDDLESEX FELS.



struction of the engine; the principal castings have been made and the pumps are now being set up at the shops, and will be in readiness for shipment as soon as the building is ready to receive them.

In order to extend the building, it was necessary to take down one of the end walls of the existing building, and this has been done. The excavation has been made for the walls of the extension and for the engine foundations, the foundations have been built, the steel frame work of the engine room floor placed in position, and the outer walls of the building carried up to a height about 15 feet above the engine room floor.

A contract for furnishing the steel work for the floor and roof was made on October 8 with Edward Kendall & Sons, and work is progressing under this contract.

On Sept. 1, 1897, a contract was made with the Lake Erie Boiler Works of Buffalo, N. Y., for furnishing a 90-inch Belpaire boiler, to be placed in the existing boiler house at this station. Steel plates for the boiler have been made by the Illinois Steel Company, and have been inspected and accepted. The work on the boiler is now in progress.

LOW-SERVICE PUMPING ENGINES.

On September 30, proposals were received for furnishing and erecting at the low-service pumping station, which is to be built a short distance from the existing pumping station at Chestnut Hill Reservoir, three vertical triple expansion pumping engines, each having a capacity of 35,000,000 gallons in twenty-four hours; and on October 20 a contract for these engines was made with the Holly Manufacturing Company of Lockport, N. Y. The only work done under this contract has been the preparation of drawings.

ENGINEERING.

The greater portion of the time of the engineering force of the distribution department has been devoted to matters relating to the several contracts which have been in progress during the year. On Jan. 1, 1897, there were 13 uncompleted contracts for labor or materials. During the past year 42 contracts have been made.

The preparation of plans and specifications for these contracts and the superintendence of the work while in progress has required the constant careful attention and nearly all of the time of the en-

gineers of this department, and has delayed the preparation of plans for works whose construction could be deferred until 1898.

The number of changes in water and gas pipes, culverts, sewers, drains, railroad tracks, telephone and telegraph conduits and poles in the several cities and towns in which the work has been done has made necessary a very large amount of negotiation with the officials of the cities, towns and corporations; and I take pleasure in acknowledging the courtesy of these officials, and their active co-operation in making the changes required.

During the winter of 1896-97 considerable work was done upon a topographical survey of the territory around Spot Pond, and some time was devoted to a study of the question of the best method of raising and improving the pond.

Surveys and plans were made of Chestnut Hill Reservoir and Spot Pond and the water works lands surrounding them, to be filed when these properties were taken on Jan. 1, 1898, in accordance with the provisions of the Metropolitan Water Act. Plans have also been made for takings of small parcels of private property in various parts of the Metropolitan Water District.

Surveys, plans and estimates have been made with reference to supplying water to Nahant, Swampscott and Stoneham.

A topographical survey has been made of the surroundings of the northern high-service reservoir site, with reference to determining the best method of disposing of the surplus material from the reservoir; and the landscape architects employed by the Metropolitan Park Commission have been asked to advise as to the disposal of the material. Additional borings and soundings have been made at the site of this reservoir.

Preliminary studies and plans have been made for the low-service pumping station at Chestnut Hill Reservoir and the northern high-service pumping station at Spot Pond.

OFFICE FORCE.

REUBEN SHIRREFFS, *Principal Office Assistant*; MORRIS KNOWLES and JOHN N. FERGUSON, *Office Assistants*.

Mr. Shirreffs has continued at the head of the designing and drafting force, and has been engaged, with his force, upon the great variety of work done in a drafting office.

A very large amount of work has been done upon the design of *structures* and appliances for the work under construction, but work

has also been continued upon the design of the Wachusett Dam. A plaster model of the rock foundation has been made, on a scale of 40 feet to an inch, with models of a straight and of a curved dam to fit the foundation. Many investigations and experiments have been made in connection with the design of this dam.

Three hundred and ninety-one plans have been made by the drafting force during the year.

Mr. Knowles, and his successor, Mr. Ferguson, have had charge of the miscellaneous work of the office, such as the procuring of supplies, making blue prints and filing of plans and records received from outside offices, as well as of many investigations and computations.

ACCIDENTS.

There have been four fatal accidents during the year in connection with the construction of the works, as follows:—

At the tunnel a laborer was killed by a blast.

On Section 4 of the Wachusett Aqueduct an Italian foreman was fatally injured by being struck by a piece of rock from a blast.

On Section 14 of the distribution system a laborer was fatally injured by the caving in of the side of the pipe trench.

On November 17 A. C. Walker, superintendent of construction for E. W. Everson & Co., was killed by the premature explosion of a blast on Cottage Street in Brookline.

In addition to these four fatal accidents, there has been one other fatality in connection with the work. On June 30 John Evans, a laborer, employed by MacRitchie & Nichol in laying the pipes across the Charles River, was drowned while attempting to save the life of a boy who was drowning while bathing in the river.

Three other men have been very seriously injured.

Appended to this report are tables of contracts, giving the amount of work done and other information, a table of the rainfall upon the Nashua water-shed for the year 1897, and a statement of cement tests made by the dam and aqueduct department.

Respectfully submitted,

FREDERIC P. STEARNS,

Chief Engineer.

BOSTON, MASS., Jan. 1, 1898.

APPENDIX.

APPENDIX NO. 1.

CONTRACTS MADE AND PENDING DURING THE YEAR 1897.

Contracts made by the City of Boston and assumed by the Metropolitan Water Board Jan. 4, 1896, relating to the Sudbury Reservoir.

1. WORK.	2. Contractor.	3. Date of Contract.	4. Date for Completion of Contract.	5. Date of Final Estimate.	6. Amount of Contract.	7. Value of Work done Dec 31, 1897.
Sudbury Dam, Southborough,*	Moulton & O'Mahoney, Boston, Mass.,	July 27, 1893,	Nov. 1, 1896,	Oct. 16, 1897,	\$539,049 67	\$539,049 67
Section A, Sudbury Reservoir,	Auguste Saucier, South Framingham, Mass.,	Aug. 27, 1894,	Dec. 1, 1894,	- -	85,000 00†	70,000 00
Section B, Sudbury Reservoir,*	Moulton & O'Mahoney, Boston Mass.,	June 12, 1895,	Dec. 1, 1896,	March 23, 1897,	76,687 35	76,687 35
Section C, Sudbury Reservoir,*	Malone & Strang, Boston, Mass.,	April 29, 1895,	Dec. 1, 1896,	Feb. 26, 1897,	99,687 54	99,687 54
Section D, Sudbury Reservoir,*	Auguste Saucier, South Framingham, Mass.,	June 25, 1895,	Dec. 1, 1896,	March 30, 1897,	78,108 32	78,108 32
Section E, Sudbury Reservoir,*	Charles Linehan, Cambridgeport, Mass.,	April 29, 1895,	Dec. 1, 1896,	Feb. 24, 1897,	53,550 30	53,550 30
Section F, Sudbury Reservoir,*	Newell & Snowling, Uxbridge, Mass.,	April 29, 1895,	Dec. 1, 1896,	Jan. 15, 1897,	51,272 51	51,272 51
Section G, Sudbury Reservoir,*	Charles Linehan, Cambridgeport, Mass.,	April 29, 1895,	Dec. 1, 1896,	Feb. 5, 1897,	29,854 29	29,854 29
Section H, Sudbury Reservoir,*	Moulton & O'Mahoney, Boston, Mass.,	April 29, 1895,	Dec. 1, 1896,	Feb. 4, 1897,	45,911 98	45,911 98
90,000 feet of iron fence along roads, Sudbury Reservoir.*	Henry Parsons, Marlborough, Mass.,	July 17, 1895,	- -	Nov. 19, 1897,	17,904 61	17,904 61
					\$1,077,026 57	\$1,062,026 57

* Contract completed.

† Approximate.

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board

1.	2.	3.	AMOUNT OF BID.		6.	
			4.	5.		
Number of Contract.	WORK.	Number of Bids.	Next to Lowest.	Lowest.	Contractor.	
1	9*	Section I, Sudbury Reservoir.	7	\$74,100 00	\$85,455 00†	H. P. Nawn, Boston, Mass.
2	10*	Section J, Sudbury Reservoir.	7	42,000 00	46,320 00†	Moulton & O'Mahoney, Boston, Mass.
3	11	Section K, Sudbury Reservoir.	7	48,210 00	45,000 00†	Blagen & Bush, Portland, Ore., and Springfield, Mass.
4	12*	Section L, Sudbury Reservoir.	10	79,252 50	78,345 50†	Moulton & O'Mahoney, Boston, Mass.
5	13	Section M, Sudbury Reservoir.	9	107,075 00	106,860 00†	H. P. Nawn, Boston, Mass.
6	14*	Section N, Sudbury Reservoir.	8	55,825 00	52,200 00†	Thomas Nevins & Son, Orange, N. J.
7	15	Section O, Sudbury Reservoir.	9	151,112 00	136,040 00†	Washburn & Washburn, New York, N. Y.
8	16	Section P, Sudbury Reservoir.	10	79,110 00	77,045 00†	H. P. Nawn, Boston, Mass.
9	17	Section Q, Sudbury Reservoir.	14	122,000 00†	118,010 00	Washburn & Washburn, New York, N. Y.
10	36*	Shutts gates and floor plates at Sudbury Dam.	4	4,800 00	4,685 00†	R. D. Wood & Co., Philadelphia, Pa.
11	58*	Gate House, Sudbury Reservoir.	6	17,300 00	17,540 00†	J. W. Bishop & Co, Worcester, Mass.
12	69	Taking from can, hauling and distributing 48-inch pipes for line from Framingham Dam No. 3 to the Sudbury Aqueduct.	1	-	1.20 per ton.	L. F. Childs, Framingham, Mass.
13	75	Laying 48-inch water pipes from Framingham Dam No. 3 to the Sudbury Aqueduct.	6	14,000 50	12,902 90†	H. P. Nawn, Boston, Mass.
14	78*	Circular Dam in Sudbury Reservoir, Southborough, Mass.	10	4,616 50	4,400 50†	Holbrook, Cabot & Daly, Newton, Mass.

* Contract completed.

† Contract based upon this bid. In the case of Contract No. 17, the contract was awarded to the lowest bidder on a combination bid for sections O and Q.

DURING THE YEAR 1897 — *Continued.*
relating to the Sudbury Reservoir.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
April 27, '96,	Dec. 1, '97,	Dec. 2, '97,	- -	\$70,343 26	\$70,343 26	1
April 27, '96,	Dec. 1, '97,	July 17, '97,	- -	43,754 13	43,754 13	2
May 8, '96,	Dec. 1, '97,	-	- -	56,167 62	56,167 62	3
April 27, '96,	Dec. 1, '97,	Dec. 3, '97,	- -	78,864 00	78,864 00	4
April 27, '96,	Dec. 1, '97,	-	- -	107,879 43	107,879 43	5
April 27, '96,	Dec. 1, '97,	Aug. 21, '97,	- -	55,227 98	55,227 98	6
April 27, '96,	Dec. 1, '97,	-	- -	138,040 00	91,500 00	7
April 27, '96,	Dec. 1, '97,	-	- -	86,430 70	86,430 70	8
April 27, '96,	Dec. 1, '97,	-	- -	123,690 00	115,897 25	9
Sept. 17, '96,	Dec. 15, '96,	Mar. 15, '97,	- -	4,918 06	4,918 06	10
April 9, '97,	July 15, '97,	Nov. 15, '97,	For building complete, \$17,546.	17,437 92	17,437 92	11
July 10, '97,	-	-	Taking from cars, hauling and distributing, \$1.20 per ton.	1,970 95	1,970 95	12
Sept. 3, '97,	Nov. 15, '97,	-	Laying 48-inch pipe, \$1.50 per lin. ft.; building gate chamber, etc., \$300.00; building all masonry with- in 40 ft. of end of proposed pipe at gate house at Fram- ingham Dam No. 3, \$850.00; earth excavation outside of pipe trench, \$0.28 per cu. yd.; rock ex- cavation, \$4.00 per cu. yd.; slope paving, \$2.50 per cu. yd.	15,269 27	15,269 27	13
Sept. 2, '97,	Dec. 1, '97,	Dec. 4, '97,	Excavation, \$0.45 per cu. yd.; riprap paving, \$1.50 per cu. yd.; cement con- crete masonry, \$5.25 per cu. yd.; rubble-stone ma- sonry, \$5.00 per cu. yd.; split stone masonry, \$5.50 per cu. yd.; dimension stone masonry, \$20.00 per cu. yd.	4,550 27	4,550 27	14
				\$302,543 50	\$750,210 84	

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board

1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	88* Section 1, Wachusett Reservoir, excavating soil and building road.	13	\$11,313 00	\$10,201 00†	Joseph D. Gennaro, Boston, Mass.
2	81 Section 2, Wachusett Reservoir, excavating 55,000 cu. yds. soil.	13	9,545 00	9,281 25†	Neill McBride, Brighton, Mass.

Contracts made by the Metropolitan Water Board

3	2	Section 2, Wachusett Aqueduct, 4,300 lin. ft. in tunnel.	19	\$133,388 00	\$122,398 00†	E. D. Smith & Co., Philadelphia, Pa.
4	3	Section 3, Wachusett Aqueduct, 8,017 lin. ft. in tunnel, 1,900 lin. ft. in open trench.	18	265,082 50	248,428 00†	E. D. Smith & Co., Philadelphia, Pa.
5	19*	Section 4, Wachusett Aqueduct, 5,700 lin. ft. masonry aqueduct.	16	106,107 50	104,733 90†	S. Casparis, Columbus, Ohio.
6	20*	Section 5, Wachusett Aqueduct, 5,300 lin. ft. masonry aqueduct.	16	97,015 50	95,079 80†	S. Casparis, Columbus, Ohio.
7	21	Section 6, Wachusett Aqueduct, 5,400 lin. ft. masonry aqueduct.	16	124,325 50	123,775 90†	S. Casparis, Columbus, Ohio.
8	22*	Section 7, Wachusett Aqueduct, 5,543 lin. ft. masonry aqueduct.	17	105,855 00†	105,565 00	S. Casparis, Columbus, Ohio.
9	23*	Section 8, Wachusett Aqueduct, Assabet Bridge.	17	54,676 25†	59,897 00	Jones, Pollard & Co., Baltimore, Md.
10	24*	Section 9, Wachusett Aqueduct, 5,268 lin. ft. masonry aqueduct.	14	146,567 50	144,185 00†	S. Casparis, Columbus, Ohio.
11	25*	Section 10, Wachusett Aqueduct, 5,290 lin. ft. masonry aqueduct.	13	174,442 00	147,861 00†	S. Casparis, Columbus, Ohio.
12	37	Section 11, Wachusett Aqueduct, open channel, 15,800 feet in length, with two small masonry dams and several stone arch road bridges.	21	89,470 00†	86,900 00	Moulton & O'Mahoney, Boston, Mass.

* Contract completed.

† Contract based upon this bid. In the case of Contract No. 22, the contract was awarded to the lowest bidder on a combination bid for sections 7, 9 and 10.

DURING THE YEAR 1897 — *Continued.**relating to the Wachusett Reservoir.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
July 14, '97	Nov. 1, '97,	Dec. 20, '97,	Earth excavation, \$0.18 per cu. yd.; broken stone or screened gravel on slopes, \$2.00 per cu. yd.; slope paving, \$1.50 per cu. yd.; dry rubble masonry and paving, \$4.00 per cu. yd.; rubble masonry laid in mortar, \$4.00 per cu. yd.; furnishing and laying 12-in. pipe culverts, \$0.60 per lin. ft.; furnishing and laying 24-in. pipe culverts, \$1.25 per lin. ft.	\$11,870 95	\$11,870 95	1
Sept. 15, '97,	Dec. 1, '97,	-	Earth excavation, \$0.16½ per cu. yd.	12,067 11	12,067 11	2
				\$23,938 06	\$23,938 06	

relating to the Wachusett Aqueduct.

Feb. 14, '96,	Dec. 1, '97,	-	-	-	\$128,720 11	\$128,720 11	3
Feb. 14, '96,	Dec. 1, '97,	-	-	-	242,601 06	242,601 06	4
May 9, '96,	Nov. 15, '97,	Dec. 8, '97,	-	-	114,167 77	114,167 77	5
May 9, '96,	Nov. 15, '97,	Dec. 23, '97,	-	-	101,179 99	101,179 99	6
May 9, '96,	Nov. 15, '97,	-	-	-	148,753 49	148,753 49	7
May 9, '96,	Nov. 15, '97,	Nov. 24, '97,	-	-	128,802 72	128,802 72	8
June 16, '96,	Nov. 1, '97,	Oct. 23, '97,	-	-	64,766 00	64,766 00	9
May 9, '96,	Nov. 15, '97,	Dec. 11, '97,	-	-	171,041 07	171,041 07	10
May 9, '96,	Nov. 15, '97,	Dec. 20, '97,	-	-	170,252 02	170,252 02	11
Sept. 22, '96,	Dec. 1, '97,	-	-	-	142,850 00†	129,400 00	12

† Approximate.

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board

1. Number of Con- tract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID.		6. Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	74	Excavation of part of Section 11 of Wachusett Aqueduct.	5	\$0.28 per cubic yard.	\$0.26 per cubic yard.	Newell & Snowling, Uxbridge; Mass.
2	87*	Section 8, Wachusett Aqueduct, granolithic covering for Assabet Bridge.	3	\$1,278 06	\$1,211 00†	W. A. Murtfeldt Company, Boston, Mass.
3	91*	Superstructure of Terminal chamber, Wachusett Aqueduct.	5	4,539 60	4,260 00†	J. W. Bishop & Co., Worcester, Mass.
4	96	Superstructure over gaging manhole, Wachusett Aqueduct.	3	2,348 00	1,584 00†	New England Granite Works, Concord, N. H.

*Contracts made by the Metropolitan Water Board
Water Pipes.*

5	8*	4,607 tons cast-iron water pipes; 4,047 tons 48-inch, 560 tons 36-inch.	-†	-†	-†	Warren Foundry & Machine Co., Phillipsburg, N. J.
6	34*	3,322 tons cast-iron water pipes; 1,457 tons 30-inch, 1,585 tons 20-inch, 280 tons 16-inch.	4	30-in., \$18.70 per ton; 20 and 16 in., \$18.90 per ton.	30-in., \$18.40 per ton; 20 and 16 in., \$18.90 per ton.†	Warren Foundry & Machine Co., Phillipsburg, N. J.
7	43*	3,558 tons cast-iron water pipes; 1,206 tons 48-inch, 2,352 tons 42-inch.	4	\$19.90 per ton.	48-in., \$18.75 per ton; 42-in., \$19.25 per ton.†	Howard-Harrison Iron Co., Bessemer, Ala.
8	44*	3,036 tons 48-inch cast-iron water pipes.	5	\$18.75 per ton.	\$18.40 per ton.†	Warren Foundry & Machine Co., Phillipsburg, N. J.
9	45*	3,175 tons 48-inch cast-iron water pipes.	-†	-†	-†	McNeal Pipe & Foundry Co., Burlington, N. J.
10	52*	616 tons special castings, .	3	Item 1, \$38.00 per ton; Item 2, \$51.00 per ton.	Item 1, \$27.40 per ton;† Item 2, \$44.20 per ton.	McNeal Pipe & Foundry Co., Burlington, N. J.
11	54	5,637 tons cast-iron water pipes; 3,020 tons 48-inch, 1,587 tons 36-inch, 1,030 tons 20-inch.	3 Bids rejected.	\$18.94 per ton.	\$18.70 per ton.	McNeal Pipe & Foundry Co., Burlington, N. J.
12	55*	3,417 tons 48-inch cast-iron water pipes.	3	\$18.94 per ton.	\$17.67 per ton.†	Camden Iron Works, Camden, N. J.

* Contract completed.

† Contract based upon this bid.

DURING THE YEAR 1897 — *Continued.**relating to the Wachusett Aqueduct — Concluded.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
July 27, '97,	Dec. 1, '97,	This contract was can- celled by agreement.	- -	-	-	1
Sept. 29, '97,	Nov. 1, '97,	Nov. 6, '97,	For whole work, \$1,211,	\$1,261 00	\$1,261 00	2
Oct. 18, '97,	Dec. 15, '97,	Dec. 24, '97,	For building complete, \$4,260,	4,260 00	4,260 00	3
Nov. 8, '97,	-	-	For building complete, \$1,584,	1,584 00	1,584 00	4
				\$1,420,239 23	\$1,406,789 23	

*relating to the Distributing System.***Water Pipes.**

Mar. 23, '96,	Dec. 15, '96,	Feb. 6, '97,	- -	\$91,687 40	\$91,687 40	5
Aug 12, '96,	Nov. 15, '96,	Jan. 15, '97,	- -	62,074 89	62,074 89	6
Oct. 20, '96,	May 1, '97,	April 27, '97,	- -	67,905 06	67,905 06	7
Oct. 23, '96,	May 1, '97,	April 27, '97,	- -	55,867 26	55,867 26	8
Oct. 20, '96,	May 1, '97,	Mar. 6, '97,	- -	58,429 39	58,429 39	9
Jan. 30, '97,	July 1, '97,	Oct. 20, '97,	3-way and 4-way branches, blow-off branches without man holes, curves, re- ducers, caps, offset pipes and sleeves, \$27.40 per ton of 2,000 pounds; manhole pipes, blow-off branches with man holes, and Y branches, \$44.20 per ton of 2,000 pounds, delivered at the pipe yards.	18,895 30	18,895 30	10
Mar. 4, '97,	Oct. 1, '97,	-	48, 36 and 20-inch pipe, \$18.20 per ton of 2,000 pounds, delivered at the pipe yards.	102,020 86	100,855 68	11
Mar. 8, '97,	Oct. 1, '97,	July 22, '97,	Straight pipe, \$17.67 per ton of 2,000 pounds, delivered at the pipe yards.	60,379 82	60,379 82	12

‡ Competitive bids were not received on these contracts; the prices in some cases were based upon previous bids.

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board
Water Pipes — Continued.*

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	56* 5,072 tons cast-iron water pipes; 1,461 tons 36-inch, 2,748 tons 24-inch, 863 tons 20-inch.	5	\$18.40 per ton (de- livery by water).	\$17.47 per ton† (de- livery by water).	Camden Iron Works, Camden, N. J.
2	57* 4,774 tons cast-iron water pipes; 1,932 tons 48-inch, 2,842 tons 36-inch.	3	\$18.94 per ton.	\$16.97 per ton.	Camden Iron Works, Camden, N. J.
3	61* 564 tons special castings, .	1	-	Item 1, \$37.00 per ton; Item 2, \$47.00 per ton †	Camden Iron Works, Camden, N. J.
4	62* 52 tons special castings, .	2	\$37.00 per ton.	\$36.50 per ton.†	Warren Foundry & Ma- chine Co., Phillips- burg, N. J.
5	63* 3,780 tons cast-iron water pipes; 1,300 tons 48½-inch, 1,270 tons 48-inch, 890 tons 36-inch, 60 tons 16-inch, 260 tons 12-inch.†	3	\$70,324 90	\$63,315 00†	Addyston Pipe & Steel Co., Cincinnati, Ohio.
6	65* 410 tons 24-inch cast-iron water pipes.	3	\$18.30 per ton.	\$17 90 per ton.†	Warren Foundry & Ma- chine Co., Phillips- burg, N. J.
7	73* 1,991 tons cast-iron water pipes; 1,071 tons 48-inch, 920 tons 36-inch.	-§	-§	-§	Camden Iron Works, Camden, N. J.
8	82 161 tons special castings, .	2	Lot No. 1, \$37.00 per ton; Lot No 2, \$57.00 per ton.	Lot No. 1, \$34.40 per ton; Lot No 2, \$44.20 per ton.†	McNeal Pipe & Foun- dry Co., Burlington, N. J.
9	Special order.* 223 tons 36-inch pipe, .	2	\$18 20	\$18 20†	Warren Foundry & Ma- chine Co., Phillips- burg, N. J.

* Contract completed.

† Contract based upon this bid.

‡ 1,876 tons of 48-inch and 36-inch pipes, called for by contract No. 63, were furnished by Camden Iron Works under contract No. 73, the Addyston Pipe and Steel Co. paying the difference in price.

DURING THE YEAR 1897 — *Continued.**relating to the Distributing System — Continued.***Water Pipes — Continued.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
Mar. 8, '97,	Oct. 1, '97,	Nov. 17, '97,	36, 24 and 20-inch pipe, \$17.67 per ton of 2,000 pounds, delivered at the pipe yards by rail.	\$89,624 48	\$89,624 48	1
Mar. 8, '97,	Oct. 1, '97,	Nov. 4, '97,	48 and 36-inch pipe, \$17.17 per ton of 2,000 pounds, delivered at the pipe yards by rail.	81,979 25	81,979 25	2
April 9, '97,	Oct. 15, '97,	Nov. 9, '97,	3-way and 4-way branches, blow-off branches without manholes, curves, reducers, caps, offset pipes and sleeves, \$37.00 per ton of 2,000 pounds, manhole pipes, blow-off branches with manholes, and Y-branches, \$47.00 per ton of 2,000 pounds, delivered at the pipe yards.	21,266 25	21,266 25	3
April 7, '97,	July 1, '97,	July 21, '97,	3-way and 4-way branches, blow-off branches without manholes, curves, reducers, caps, offset pipes and sleeves, \$36.50 per ton of 2,000 pounds delivered at the pipe yards.	1,916 69	1,916 69	4
April 10, '97,	Aug. 15, '97,	Oct. 20, '97,	Straight pipe, \$16.75 per ton of 2,000 pounds; 2,280 tons to be delivered at the pipe yards, 1,500 tons to be delivered at Framingham Centre.	30,473 48	30,473 48	5
April 26, '97,	June 10, '97,	July 13, '97,	Straight pipe, \$17.90 per ton of 2,000 pounds.	7,353 03	7,353 03	6
July 26, '97,	Sept. 15, '97,	Oct. 26, '97,	48-inch, Class A pipe, \$17.80 per ton of 2,000 pounds; 48-inch, Class B pipe, \$17.67 per ton of 2,000 pounds; 36-inch, \$17.80 per ton of 2,000 pounds, delivered at the pipe yards.	35,343 26	35,343 26	7
Aug. 30, '97,	Dec. 15, '97,	-	3-way and 4-way branches, blow-off branches without manholes, curves, reducers, caps, offset pipes and sleeves, \$34.40 per ton of 2,000 pounds; manhole pipes, blow-off branches with manholes, and Y-branches, \$44.20 per ton of 2,000 pounds, delivered at the pipe yards.	6,081 41	5,108 26	8
Mar. 15, '97,	-	May 11, '97,	Straight pipe, \$18.20 per ton of 2,000 pounds, delivered at the pipe yard.	4,055 36	4,055 36	9

§ Competitive bids were not received on these contracts; the prices in some cases were based upon previous bids.

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board
Water Pipes—Concluded.

1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1 Special order.*	104 tons cast-iron water pipes; 67 tons 36-inch, 37 tons 30-inch.	-†	-†	-†	Camden Iron Works, Camden, N. J.
2 Special order.*	72 tons cast-iron water pipes; 25 tons 4-inch, 35 tons 6-inch, 12 tons 14-inch.	-†	-†	-†	R. D. Wood & Co., Philadelphia, Pa.
3 Special order.*	113 tons 36-inch cast-iron pipe.	-†	-†	-†	Camden Iron Works, Camden, N. J.
4 Special order.*	62 tons special castings; 52 tons 16-inch pipe.	-†	-†	-†	Camden Iron Works, Camden, N. J.

Pipe Laying.

5	30*	Laying 11,500 lin. ft. of 48-inch and 1,500 ft. of 36-inch water pipes in Malden, Melrose and Stoneham (sections 7 and 13); also laying 1,480 ft. of 48-inch water pipes under a modification of the contract.	4	\$27,838 20	\$27,718 50†	The C. H. Eglee Co., Boston, Mass.
6	31*	Laying 18,300 lin. ft. 48-inch water pipes in Cambridge and Somerville (sections 4 and 11).	6	42,561 90†	42,421 70	Snyder & Williams, Dayton, Ohio.
7	39*	Laying 7,330 lin. ft. of 30-inch cast-iron water pipes in Malden (section 14).	8	9,005 60	8,208 60†	Collins & Ham, South Boston, Mass.
8	41*	Laying 10,000 lin. ft. of 16-inch cast-iron water pipes in Revere (section 16).	11	5,441 50	4,723 00†	George Goodhue, Concord, N. H.
9	42*	Laying 14,400 lin. ft. of 20-inch cast-iron water pipes in Malden and Medford (section 18).	13	10,387 00	9,798 25†	Collins & Ham, South Boston, Mass.
10	47	Furnishing and laying water pipes across Charles River, between Boston and Cambridge (sections 3 and 10).	2	79,850 00	38,992 00†	MacRitchie & Nichol, Chicago, Ill.
11	48*	Furnishing and laying water pipes across Mystic River, between Somerville and Medford (section 5).	2	55,465 00	44,682 00†	MacRitchie & Nichol, Chicago, Ill.

* Contract completed.

† Competitive bids were not received on these contracts; the prices in some cases were based upon previous bids.

‡ Contract based upon this bid.

DURING THE YEAR 1897 — *Continued.**relating to the Distributing System — Continued.***Water Pipes — Concluded.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec 31, 1897.	
April 13, '97,	-	Aug. 28, '97,	36 and 30 inch pipe, \$17.90 per ton of 2,000 pounds.	\$1,859 45	\$1,859 45	1
May 13, '97,	-	June 22, '97,	14-inch, 6-inch and 4-inch pipes, \$17.88 per ton of 2,000 pounds.	1,296 88	1,296 88	2
Oct. 5, '97,	-	Nov. 17, '97,	Straight pipe, \$17.67 per ton of 2,000 pounds.	1,990 85	1,990 85	3
Oct. 25, '97,	-	Dec. 20, '97,	16-inch pipe, \$17.30; special castings, \$34.40 per ton of 2,000 pounds, delivered at the pipe yards.	3,053 01	3,053 01	4
				\$804,153 38	\$801,415 05	

Pipe Laying.

June 10, '96,	Nov. 1, '96,	June 10, '97,	- -	\$32,150 96	\$32,150 96	5
Aug. 6, '96,	Dec. 1, '96,	July 16, '97,	- -	48,469 33	48,469 33	6
Oct. 8, '96,	May 15, '97,	Aug. 14, '97,	- -	11,759 81	11,759 81	7
Oct. 8, '96,	Dec. 1, '96,	June 16, '97,	- -	4,925 11	4,925 11	8
Oct. 8, '96,	May 15, '97,	Sept. 17, '97,	- -	10,868 97	10,868 97	9
Feb. 24, '97,	Oct. 1, '97,	-	Furnishing and laying 36- inch cast-iron pipe below grade 5 on section 3, \$16.50 per lin. ft.; furnishing and laying 36-inch cast-iron pipe below grade 5 on sec- tion 10, \$18.00 per lin. ft.	38,992 00	38,426 85	10
Feb. 24, '97,	Oct. 1, '97,	Dec. 15, '97,	Furnishing and laying 36- inch cast-iron pipe below grade 5, \$15.50 per lin. ft.	43,194 63	43,194 63	11

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board
Pipe Laying—Continued.

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	58	Laying 12,900 lin. ft. of 48- inch, and 4,300 ft. of 16- inch cast-iron water pipes in Cambridge, Somerville and Medford (sections 11 and 18).	10	\$34,012 75	\$30,274 00	H. A. Hanscom & Co., West Medford, Mass.
2	59*	Laying 2,940 lin. ft. of 48- inch cast-iron water pipes in Somerville (section 4).	13	7,359 39	6,619 45†	C. A. & C. E. Trum- bull, Lawrence, Mass.
3	60*	Laying 12,100 lin. ft. of 48- inch, and 8,000 lin. ft. of 42-inch cast-iron water pipes in Malden, Everett and Chelsea (sections 6 and 8).	10	60,864 70†	48,274 00	The C. H. Eglee Co., Boston, Mass.
4	64*	Laying 11,000 lin. ft. of 36- inch cast-iron water pipes in Malden, Melrose and Stoneham (section 13).	19	23,815 00†	23,323 00	A. W. Bryne Con- struction Co., West Medford, Mass.
5	66*	Laying 8,900 lin. ft. of 48- inch cast-iron water pipes in Brookline and Brighton (section 9).	15	20,042 50	16,639 25†	E. W. Everson & Co., Providence, R. I.
6	70*	Laying 7,450 lin. ft. of 36- inch cast-iron water pipes in Brighton and Newton (section 23).	14	9,288 50	8,453 50†	Bruno & Salomone, E. Boston, Mass.
7	71	Laying 15,800 lin. ft. of 48- inch cast-iron water pipes in Brookline and West Roxbury (section 19).	13	34,819 00	34,269 00†	E. W. Everson & Co., Providence, R. I.
8	77	Laying 11,500 lin. ft. of 20- inch cast-iron water pipes in Newton and Water- town (section 24).	16	9,040 25	8,524 00†	S. W. Freescoll, Read- ing, Pa.
9	79	Laying 16,000 lin. ft. of 24- inch cast-iron water pipes in Dorchester, Milton and Quincy (section 21).	12	13,591 75	12,402 30†	Saucier & O'Brien, Boston, Mass.
10	86	Laying water pipes across Malden River in Mal- den (section 6).	5	9,198 00	8,736 00†	Moore & Co., and Wm. H. Ward, Boston, Mass.
11	90*	Laying 2,750 lin. ft. of 16- inch and 1,100 lin. ft. of 12-inch cast-iron water pipes in Chelsea and Re- vere (section 17).	6	2,674 75	2,579 50†	H. A. Hanscom & Co., West Medford, Mass.
12	92	Laying 2,400 lin. ft. of 48- inch cast-iron water pipes in Brighton (section 1).	9	5,347 50	4,636 50†	Malone & McHale, Mt. Auburn, Mass.

* Contract completed.

† Contract based upon this bid.

DURING THE YEAR 1897 — *Continued.**relating to the Distributing System — Continued.***Pipe Laying — *Continued.***

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
April 6, '97,	Nov. 1, '97,	-	Laying 48-inch pipe, \$2.18 per lin. ft.	\$35,503 40	\$35,503 40	1
April 2, '97,	Oct. 1, '97,	Dec. 15, '97,	Laying 48-inch pipe, \$1.63 per lin. ft.	6,741 42	6,741 42	2
April 2, '97,	Nov. 1, '97,	Oct. 18, '97,	Laying 48-inch pipe, \$2.37 per lin. ft.; 42-inch pipe, \$1.84 per lin. ft.	61,681 92	61,681 92	3
May 13, '97,	Oct. 1, '97,	Nov. 30, '97,	Laying 36-inch pipe, \$0.98 per lin. ft.	25,443 19	25,443 19	4
June 28, '97,	Nov. 1, '97,	Dec. 16, '97,	Laying 48-inch pipe, \$1.25 per lin. ft.	17,750 30	17,750 30	5
Aug. 5, '97,	Dec. 1, '97,	Dec. 30, '97,	Laying 36-inch pipe, \$1.06 per lin. ft.	9,895 24	9,895 24	6
Aug. 3, '97,	June 1, '98,	-	Laying 48-inch pipe, \$1.70 per lin. ft.	34,269 00	23,366 97	7
Sept. 2, '97,	Dec. 1, '97,	-	Laying 20-inch pipe, \$0.59 per lin. ft.	9,300 00	9,000 00	8
Sept. 2, '97,	Dec. 1, '97,	-	Laying 24-inch pipe, \$0.68 per lin. ft.	12,402 30	11,692 58	9
Oct. 5, '97,	Jan. 1, '98,	-	Laying 36-inch pipe, includ- ing coffer-dam and inci- dental work, \$13.50 per lin. ft.	8,736 00	7,000 00	10
Oct. 16, '97,	Dec. 1, '97,	Dec. 15, '97,	Laying 16 inch pipe, \$0.55 per lin. ft.; 12-inch pipe \$0.52 per lin. ft.	2,534 72	2,534 72	11
Oct. 21, '97,	Dec. 1, '97,	-	Laying 48-inch pipe, \$1.49 per lin. ft.	5,000 00	4,000 00	12

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board
Pipe Laying — Concluded.

1. Num- ber of Con- tract.	2. WORK.	3. Num- ber of bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	97	Laying 420 lin. ft. of 48-inch, and 660 lin. ft. of 20-inch cast-iron water pipes across the Mystic River in Medford.	-*	-*	Cheney & Trumbulls, Boston, Mass.
2	98†	Laying 1,800 lin. ft. of 12-inch cast-iron water pipes in Revere and East Boston (section 16).	-*	-*	H. A. Hanscom & Co., West Medford, Mass.
3	Agreement.†	Laying 418 lin. ft. 48-inch cast-iron water pipes in Malden, under Boston & Maine R. R. (section 7).	-*	-*	The C. H. Egles Co., Boston, Mass.

Miscellaneous.

4	4†	20 36-inch water valves, .	10	\$9,400 00†	\$7,800 00	Joniah H. Long, Boston, Mass.
5	28†	52 water valves; 6 24-inch, 6 20-inch, 20 16-inch, 20 12-inch.	3	4,832 00	4,608 00†	Joniah H. Long, Boston, Mass.
6	40†	Pipe bridge over Boston & Maine R. R. at Walnut Street, Somerville.	3	2,615 00	2,497 00†	Boston Bridge Works, Boston, Mass.
7	46	Pumping engine for the Chestnut Hill high-service pumping station in Boston.	-*	-*	-*	The Edward P. Allis Co., Milwaukee, Wis.
8	49†	Cast-iron frames and covers.	8	1,072 50	1,029 60†	Chelmsford Foundry Co., Boston, Mass.
9	50†	Steel work for chambers for 36-inch valves.	4	1,089 00	1,079 40†	New Jersey Steel & Iron Co., Trenton, N. J.
10	51	73 water valves; 30 12-inch, 10 16-inch, 6 20-inch, 6 24-inch, 6 30-inch, 15 36-inch.	6	12,546 00	11,390 00†	Kennedy Valve Mfg. Co., New York, N. Y.
11	67	54 water valves; 24 36-inch, 6 30-inch, 8 24-inch, 6 20-inch, 10 12-inch.	2	12,432 00	11,160 00†	Camden Iron Works, Camden, N. J.
12	72	3 pumping engines for the Chestnut Hill low-service pumping station in Boston.	5	195,000 00	136,500 00†	Holly Mfg. Co., Lockport, N. Y.
13	76	90-inch Belpaire boiler for the Chestnut Hill high-service pumping station in Boston.	3	15,000 00	13,750 00†	Lake Erie Boiler Works, Buffalo, N. Y.

* Competitive bids were not received on this contract.

† Contract completed.

DURING THE YEAR 1897 — *Continued.*

relating to the Distributing System — Continued.

Pipe Laying — *Concluded.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items* of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897.	
Nov. 13, '97,	Jan. 1, '98,	-	Laying 48-inch pipe, \$3.20 per lin. ft.; 20-inch pipe, \$0.65 per lin. ft.	\$2,649 90	\$1,800 00	1
Nov. 22, '97,	Dec. 15, '97,	Dec. 15, '97,	Laying 12-inch pipe, \$0.55 per lin. ft.	1,166 93	1,166 93	2
Sept. 23, '97,	-	Oct. 22, '97,	Laying 48-inch pipe, \$3.75 per lin. ft.	1,903 45	1,903 45	3
				\$425,338 58	\$409,275 78	

Miscellaneous.

Mar. 27, '96,	Dec. 12, '96,	Nov. 5, '97,	-	-	\$9,400 00	\$9,400 00	4
June 1, '96,	Nov. 1, '96,	Sept. 27, '97,	-	-	4,608 00	4,608 00	5
Oct. 3, '96,	Dec. 1, '96,	Apr. 7, '97,	-	-	2,497 00	2,497 00	6
Jan. 1, '97,	July 1, '98,	-	Price of engine complete, \$114,000.		114,000 00	30,000 00	7
Jan. 23, '97,	Mar. 23, '97,	Apr. 3, '97,	\$1.20 per pound, . . .		1,108 02	1,108 02	8
Jan. 29, '97,	Apr. 29, '97,	May 22, '97,	\$35.98 per set, . . .		1,091 55	1,091 55	9
Feb. 15, '97,	Nov. 15, '97,	-	12-inch valves, \$41.00; 16-in., \$68.00; 20-inch, \$130.00; 24-inch, \$175.00; 30-inch, \$275.00; 36-inch, \$400 00.		11,390 00	11,390 00	10
June 19, '97,	Nov. 6, '97,	-	36-inch valves, \$530.00; 30- inch, \$370.00; 24-inch, \$190.00; 20-inch, \$140.00; 12-inch, \$60.00.		17,900 00	12,750 00	11
Oct. 20, '97,	July 20, '98,	-	Price of each engine com- plete, \$45,500.		136,500 00	-	12
Sept. 1, '97,	Mar. 15, '98,	-	Price of boiler complete, \$13,750.		13,750 00	6,000 00	13

† Contract based upon this bid.

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board
Miscellaneous — Concluded.

1. Number of Con- tract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID.		6. Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	80	Addition to Chestnut Hill pumping station.	3	\$73,980 00	\$47,979 00*	C. A. Dodge & Co. Boston, Mass.
2	83	Pipe bridge over the Mys- tic River in Medford (abutments).	10	3,640 00	3,390 00*	Cheney & Trumbulls, Boston, Mass.
3	84	Pipe bridge over the Mys- tic River in Medford (superstructure).	5	4,087 00	3,980 00*	New Jersey Steel & Iron Co., Trenton, N. J.
4	85	Addition to Chestnut Hill pumping station (iron work).	6	4,027 00	3,140 00*	Edward Kendall & Sons, Cambridge- port, Mass.
5	88	19 water valves, . . .	-†	-†	-†	Coffin Valve Co., Bos- ton, Mass.
6	89	Gate house and connec- tions at Spot Pond, Stoneham, Mass.	4	26,475 00	19,932 50*	The C. H. Eglee Co., Boston, Mass.
7	93	Pipe bridge over the Bos- ton & Albany Railroad at St. James Street, New- ton.	5	1,514 00	1,500 00*	Boston Bridge Works, Boston, Mass.
8	94	Steel work for covering valve chambers.	8	1,590 00	1,496 00*	New England Struc- tural Co., East Ever- ett, Mass.
9	95	Building and erecting hand travelling crane, Chest- nut Hill pumping station.	6	1,970 00*	1,550 00†	Brown Hoisting & Conveying Machine Co., Cleveland, Ohio.

* Contract based upon this bid.

† Competitive bids were not received on this contract.

DURING THE YEAR 1897 — *Continued.**relating to the Distributing System. — Concluded.***Miscellaneous — *Concluded.***

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1897.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1897	
Sept. 21, '97,	Mar. 1, '98,	-	For whole work, \$47,979, .	\$47,979 00	\$23,000 00	1
Sept. 17, '97,	Dec. 15, '97,	-	For whole work, \$3,390, .	3,540 28	3,000 00	2
Sept. 23, '97,	Dec. 15, '97,	-	For whole work, \$3,980, .	3,980 00	3,000 00	3
Oct. 8, '97,	Jan. 15, '98,	-	For whole work, \$3,140, .	3,140 00	1,500 00	4
Oct. 2, '97,	Jan. 11, '98,	-	16-inch valves, \$108.00 per valve, 12-inch valves, \$73.50 per valve.	1,845 00	324 00	5
Oct. 13, '97,	Dec. 15, '97,	-	Building and maintaining coffer-dams, pumping, etc., \$6,000.00; earth excava- tion, \$0.55 per cu. yd.; rock excavation, \$4.25 per cu. yd.; Portland cement concrete masonry, \$7.50 per cu. yd.; dimension stone masonry, \$20.00 per cu. yd.	21,559 74	19,000 00	6
Oct. 23, '97,	Dec. 1, '97,	-	For whole work, \$1,500, .	1,500 00	1,000 00	7
Oct. 23, '97,	Dec. 23, '97,	-	\$29.92 per set, . . .	1,496 00	359 04	8
Dec. 8, '97,	Feb. 1, '98,	-	For whole work, \$1,970, .	1,970 00	-	9
				\$399,254 59	\$130,027 61	

† Informal bid.

CONTRACTS MADE AND PENDING DURING THE YEAR 1897 — *Concluded.*

Summary of Contracts.

	Approximate Amount of Con- tracts.	Value of Work done Dec. 31, 1897.
Sudbury Reservoir, uncompleted portions of 10 contracts made by the city of Boston and assumed by the Metropolitan Water Board,	\$565,026 57	\$550,026 57
Sudbury Reservoir, 14 contracts made by the Metropolitan Water Board,	802,543 59	750,210 84
Wachusett Reservoir, 2 contracts,	23,938 06	23,938 06
Wachusett Aqueduct, 14 contracts,	1,420,239 23	1,406,789 23
Distributing System, 56 contracts,	1,614,587 55	1,326,559 44
Total of 96 contracts made and pending during the year 1897,	\$4,426,335 00	\$4,057,524 14
13 contracts completed in 1896,	651,449 77	651,449 77
Total of 109 contracts,	\$5,077,784 77	\$4,708,973 91

APPENDIX No. 2.

Monthly Rainfall, in Inches, during 1897, at Four Places on the Watershed of the Nashua River.

	Princeton.	Jefferson.*	So. Clinton.	Sterling.
Elevation above mean sea level (feet),	1,060†	815†	310	560†
January,	2.92	3.95	3.39	3.59
February,	3.01	3.03	2.86	2.53
March,	4.08	3.92	4.21	3.81
April,	2.22	2.18	2.63	2.24
May,	5.64	4.84	4.60	5.18
June,	5.39	4.95	4.85	5.25
July,	10.00	8.48	7.06	9.06
August,	3.57	2.71	3.94	3.66
September,	2.17	1.70	2.21	1.66
October,	0.97	1.00	0.92	0.87
November,	7.43	8.03	7.45	7.58
December,	6.23	6.87	6.22	6.31
Totals,	53.63	51.66	50.84	51.74

* Rainfall for months of January and February taken at Quinepozet; from March 1 to April 18 the figures given are an average of the records at Princeton and Sterling.

† Elevations taken from maps of State topographical survey.

APPENDIX No. 3.

TESTS OF CEMENTS USED IN THE CONSTRUCTION OF THE WACHUSETT AQUEDUCT, MADE AT THE OFFICE OF THE METROPOLITAN WATER BOARD, DAM AND AQUEDUCT DEPARTMENT, CLINTON, MASS.

Sampling.

Samples were taken from every car load lot. The man taking them recorded the car number, the brand of cement, the number of barrels or bags in the lot and the date when sampled.

If the cement was a new brand upon the work, samples were taken in the proportion of one for every five barrels in the lot. After the brand had been used on the work for some time and its characteristics were known, this proportion was changed to one in every ten barrels. These samples were taken at random from all parts of the car load, and each barrel selected was given a distinguishing number.

If the cement was packed in barrels, each, when sampled, was tapped near the centre of the head with a $1\frac{1}{4}$ inch bit, and about 300 grammes of cement were removed by the use of a semi-cylindrical iron scoop about 18 inches long and 1 inch in diameter. The hole in the barrel head was then plugged up, and the sample placed in a small paper bag bearing the same distinguishing number as the barrel. If the cement came in bags, each bag sampled was untied, and the sample taken from the middle of the bag with the scoop.

Sieve Tests.

One or more sieve tests were made from each car load. One hundred grammes of cement were weighed out from one particular sample, and passed through the various sieves. The residue on each was weighed and noted as percentage retained.

If a Portland cement was being tested, it was first sifted through a sieve having 180 meshes to the linear inch; the residue was weighed and recorded,

and then passed through a sieve having 100 meshes to the linear inch; this residue was in turn weighed and recorded, and then passed through a sieve having 50 meshes to the linear inch. If the results varied from those usually found for that particular brand of cement, other samples from the same lot were sifted. With natural cements the finest sieve used was the one having 100 meshes to the linear inch. The sieves had a diameter of about 7 inches and a height of 3 inches.

Tests for Soundness.

When a new brand of cement was received, or when for any reason it was desired to test the soundness of a cement, the process was as follows: —

After making up the briquettes for the tensile strength test, a mixture was made of what remained of the samples representing the particular car load, and from this mixture two pats of neat cement were made, the cement being gaged with water enough to make it, when mixed, firmly plastic. These pats were about 4 inches in diameter, $\frac{1}{2}$ an inch thick at the centre, and were worked down to a very thin edge. They were put upon small plates of glass. One of the pats was covered with a damp cloth, to protect it from drying cracks, and left in the air until it attained its final set. It was then, while still remaining upon the glass, immersed in cold water, and was examined from time to time for radial cracks, warping, separation from the glass, discoloration and other signs of unsoundness. The other pat was placed as soon as made upon a shelf in the Faija heater, and allowed to set in damp air at a temperature of about 110° F. When this pat attained its final set it was immersed, while still upon the glass, in a pan of water at the bottom of the heater, maintained at a temperature of about 112° F. This pat was also examined from time to time for signs of unsoundness.

Time of Setting.

The time of setting of both neat cement and mortar was observed by tests with the Gillmore needles on one or more samples from each car load. The length of time after gaging when a cement will hold the light needle $\frac{1}{12}$ of an inch in diameter loaded with a $\frac{1}{4}$ -pound weight was assumed as the period of the beginning of setting, or of the *initial set*. Observations were then continued, using a heavy needle $\frac{1}{8}$ of an inch in diameter, loaded with a 1-pound weight. When the cement was sufficiently firm to bear this needle without any impression, it was assumed to have attained its *final set*.

Method of Making Briquettes for Tensile Strength Test.

Briquettes were made from each sample, and not from a mixture of all of the samples representing each car load. The briquettes of neat cement were made one at a time, except in case more than one was required from each sample, when two were mixed at a time.

When more than two briquettes made of cement and sand were required from the same samples, as was sometimes the case where long-time tests were provided for, from 5 to 8 briquettes were mixed at a time in the Faija mixing machine.

In the tests of mortar, standard quartz sand was used of practically such size that it would pass through a No. 20 sieve and be retained on a No. 30 sieve.

The material for the briquettes was first carefully weighed, just enough being used to leave a slight excess when the mould was filled, and then placed on a ground-glass mixing slab. The water required was then added, and the mixture thoroughly worked with a small trowel. Just enough water was used in gaging to bring the mixture to such a consistency that after a thorough working it tended to cling together slightly. When ramming it into the mould it was stiffly plastic, finishing off wet on the surface, but not enough so to pull away from the mould to any extent when smoothed off with a trowel.

For natural cements, mixed neat, about 27 or 28 per cent. by weight of water was used, and for Portland cements from 16 to 25 per cent., varying with different brands and sometimes with different samples of the same brand.

With natural cement mortar, mixed with one part of cement to one part of sand, about 16 or 17 per cent. of water was used; with Portland cement mortar, mixed with one part of cement to two parts of sand, from 10 to 12 per cent. of water was used.

After the water was added and the ingredients were thoroughly mixed, the mould was placed upon a glass slab and the cement was put in the mould in three layers. Each layer received a thorough ramming by hand, with about 40 blows from a wooden rammer about 8 inches long and having a face $1\frac{1}{4}$ inches long and $\frac{7}{8}$ of an inch wide. The briquette was then left on the glass slab until it attained its *final set*, and about two hours later was immersed in water.

The briquettes when immersed were placed on edge in wooden tanks, through which there was a small but constant circulation of fresh water. They remained in these tanks until the time for breaking arrived.

In the case of the mortar briquettes, the sand and cement were thoroughly mixed together when dry, then thoroughly worked by hand or

machine after the water was added, and rammed into the moulds in the same manner as the neat cement.

The briquettes had a section of 1 square inch, and were of the standard form recommended by the American Society of Civil Engineers.

The standard mortar tests, in the case of natural cement, were a mixture of 1 part by weight of sand to 1 part of cement, and in the case of Portland cements of 2 parts by weight of sand to 1 part of cement. The corresponding proportions by measure were for Rosendale natural cement 1.08 parts of sand to 1 part of cement, for Atlas Portland cement 2.62 parts of sand to 1 part of cement and for Giant Portland cement 2.48 parts of sand to 1 part of cement; the cement being packed practically as received from the manufacturer and the sand as though thrown loosely into a barrel.

The results of the tests of natural and Portland cements are given in the accompanying tables : —

Tabulation of Cement Tests for All Brands of Natural Cement, of which 900 Barrels or More were used in the Construction of the Wachusett Aqueduct in 1896 and 1897.

BRAND.	Number of Barrels used.	Composition of Brickette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.											
			Per Cent. Residue on No. 60 Sieve, Square Inch.	Per Cent. Residue on No. 100 Sieve, Square Inch.	Per Cent. Residue on No. 180 Sieve, Square Inch.	Minutes to bear Light Wire.	Minutes to bear Heavy Wire.	ONE DAY.		SEVEN DAYS.		TWENTY-EIGHT DAYS.		THREE MONTHS.		SIX MONTHS.		ONE YEAR.	
								Number of Brickettes.	Pounds per Square Inch.	Number of Brickettes.	Pounds per Square Inch.	Number of Brickettes.	Pounds per Square Inch.	Number of Brickettes.	Pounds per Square Inch.	Number of Brickettes.	Pounds per Square Inch.	Number of Brickettes.	Pounds per Square Inch.
Beach, . . .	8,100	{ Neat 1 to 1	7.6	20.6	-	43	77	864	122	606	135	59	350	52	390	14	458		
Hoffman, . . .	43,024	{ Neat 1 to 1	5.9	17.1	-	36	66	-	-	608	103	64	168	59	320	14	305		
Norton, . . .	60,877	{ Neat 1 to 1	8.1	22.4	-	29	51	4,339	117	2,729	130	102	200	77	345	6	417		
Union, . . .	900	{ Neat 1 to 1	1.3	9.9	18.1	10	26	6,244	115	1,979	128	75	204	40	342	-	-		
						35	76	-	-	1,967	95	55	160	40	336	-	-		
						10	26	183	164	163	167	137	187	67	273	12	346		
						10	20	-	-	163	156	36	206	66	312	15	506		
Total, . . .	112,901	{ Neat 1 to 1	7.1	20.1	-	35	76	11,680	117	5,507	131	378	202	243	326	32	408		
						32	63	-	-	5,452	102	296	178	242	323	35	363		

APPENDIX No. 4.

METROPOLITAN WATER ACT.

[Chapter 488 of the Acts of the Year 1895.]

AN ACT TO PROVIDE FOR A METROPOLITAN WATER SUPPLY.

Be it enacted, etc., as follows:

METROPOLITAN WATER BOARD.

SECTION 1. The governor, by and with the advice and consent of the council, shall appoint three water commissioners, who shall constitute the Metropolitan Water Board. Said commissioners shall hold office, one for the term of five years, one for the term of four years and one for the term of three years, beginning with the first Monday in May in the year eighteen hundred and ninety-five; and in the year eighteen hundred and ninety-eight, and annually thereafter, the governor shall appoint, as aforesaid, one member of said board to hold office for the term of three years, beginning with the first Monday in May in the year of his appointment. The governor, with the consent of the council, may remove any member of said board, and may appoint for the residue of the term, in the same manner in which the original appointment was made, a commissioner to fill any vacancy occurring by removal, resignation or otherwise. One of said commissioners shall be always a citizen of Boston, one shall be always a citizen of one of the other cities or towns in the water district hereinafter described, and one shall be always a citizen of this Commonwealth. The chairman of said board shall receive a salary of five thousand dollars a year, and the other members a salary of four thousand five hundred dollars a year.

Commissioners.

Terms of service.

Governor and council may remove.

Residence of commissioners.

Compensation.

OFFICERS AND ACCOUNTS.

SECTION 2. The governor shall, as soon as may be after the appointment of said board, and annually thereafter on or before the first Monday of May, designate one of their number to serve as chairman for the ensuing year; said board shall from time to time appoint an engineer, secretary, and such other

Governor to designate chairman.

Board may appoint and remove officers and agents.

Accounts.

Report to the legislature.

agents, officers, clerks and other employees as said board may deem necessary, shall determine the duties and compensation of such appointees, and may remove the same at pleasure, and may employ counsel; shall at all times keep full, accurate and separate accounts of the doings, receipts, expenditures, disbursements, assets and liabilities of said board, and include an abstract of the same in an annual report to the general court on or before the first Wednesday in January in each year, such report to be numbered as one of the series of public documents; and four thousand five hundred copies thereof to be printed annually.

METROPOLITAN WATER DISTRICT.

Board to construct and maintain water works.

Metropolitan water district.

To supply cities and towns within ten miles of state house.

May supply water companies in said district.

May supply other cities, towns and water companies.

Distribution of money.

Delivery of water.

SECTION 3. Said board, acting for the Commonwealth, shall construct, maintain and operate a system of metropolitan water works substantially in accordance with the plans and recommendations of the state board of health, contained in their report to the legislature of the year eighteen hundred and ninety-five, and shall provide thereby a sufficient supply of pure water for the following named cities and towns, and the inhabitants thereof, to wit:—The cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop, which cities and towns shall constitute the Metropolitan Water District; shall secure and protect the purity of said water; shall on application furnish water to any city or town aforesaid that at the time of application owns its water pipe system; shall on application admit any other city or town, any part of which is within ten miles of the state house, into said water district, and furnish water to the same on the terms prescribed by this act for the cities and towns aforesaid, and on such payment of money as said board may determine; shall on application furnish water to any water company owning the water pipe system in any town within said ten miles, on such water company assuming the assessments of the town, if any, and making such payment of money as said board may determine; and may from time to time furnish water to any other city, town or water company, on such payment of money as said board may determine. All payments of money aforesaid shall be distributed to the cities and towns in said district in proportion to the total amount of the annual assessments theretofore paid by them respectively. Said board shall furnish said water to the city,

town or company, by delivering the same into a main water pipe, reservoir or tank of the city, town or company, under sufficient pressure for use without local pumping, unless delivered in some other manner by mutual agreement between the parties interested; and shall have the direction and control of the connections between the metropolitan and local systems. Said board may utilize the fall of water at any dam under their charge, and may thereby produce power or electricity, and may transmit such power or electricity by pipes, wires, or other suitable means, and sell the same, or the right to use such water, by written or other contract, to run for a term not exceeding fifteen years. Any person or corporation authorized by said board shall have all the powers relating to the production, sale and transmission of power and electricity given by this act to said board.

May transmit and sell power or electricity.

May authorize persons and corporations to sell and transmit power and electricity.

[Stoneham to be admitted into Metropolitan Water District. Acts 1897. Chap. 473.]

WATER SOURCES.

SECTION 4. Said board may take, by purchase or otherwise, the waters of the south branch of the Nashua river, at and above a point above the dam of the Lancaster Mills in the town of Clinton, but shall allow not less than twelve million gallons of water to flow from a reservoir above said dam in each week, and such further quantity, not exceeding twelve million gallons a week, as the owner of said mills shall from time to time certify to be necessary for use therein and in other buildings now or hereafter owned by him, for domestic or manufacturing purposes, other than the production of water power, and said board, in regulating the flow of said quantities, shall, as far as practicable, conform to any reasonable request in writing of the owner of said mills; said board may also take the waters of Sandy pond, so-called, in the town of Clinton, and the waters which may flow into and from said pond or river, and the tributaries thereof above said point; may take such water rights as they deem necessary connected with said waters; said board shall forthwith, after taking the waters of said Nashua river, take by purchase or otherwise all real estate which will be submerged or flooded, or submerged to an increased depth, by the construction of the proposed reservoir on the Nashua river hereinafter provided for, and all parcels of real estate above the dam of said reservoir used for mill purposes and owned by the owner of any mill property of which any part will be submerged or flooded by the construction of said reservoir, includ-

May take south branch of Nashua river.

To furnish water for the use of Lancaster Mills.

To conform to request of owner of mills.

May take Sandy pond.

To take real estate submerged or flooded on Nashua river, and machinery used on such real estate.

To take lands, ponds, etc., west of Chestnut Hill reservoir.

To take pumping station at Chestnut Hill reservoir and land surrounding same.

To take Spot pond and land surrounding same and pumping stations thereon.

May take other lands and property.

ing all the machinery used on such real estate and tenements for operatives ; shall, on or before the first day of January in the year eighteen hundred and ninety-eight, take all the lands and all the ponds, basins, reservoirs, filter beds, dams, aqueducts, conduits, pumping stations, pipes, pumps and other property held by the city of Boston for the purpose of supplying water or for the purpose of storing or of protecting or preserving the purity of the water, and situated westward of Chestnut Hill reservoir in said city and westward of the intersections of the main pipes to be laid from Chestnut Hill reservoir to Spot pond, with the main pipes which convey water from the Mystic distributing reservoir ; also the pumping station at Chestnut Hill reservoir and lands under and surrounding the same, and the pipes and aqueduct leading thereto ; also Spot pond, so-called, in or near the town of Stoneham, and the lands under and surrounding the same, now owned by the cities of Malden and Medford and the town of Melrose, or either of them, held for the purpose of water supply or of protecting or preserving the purity of the water, and the pumping stations and pumps thereon ; any or all of the aforesaid lands to be taken in fee or otherwise, as said board may determine. Said board may take any other lands in fee, easements, rights and other property that said board may deem necessary or desirable for carrying out the powers and duties conferred upon them by this act.

RECORD OF TAKING.

To record description of land taken.

Ponds, lands, etc., taken for the Commonwealth.

To record description of land entered upon for use, and purposes for which, and time to be used.

SECTION 5. Said board, to take any property by right of eminent domain, shall sign and cause to be recorded in the registry of deeds for the county and district in which the property to be taken is situated, a statement containing a description thereof, as certain as is required in a common conveyance of land, and stating that the same is taken for the metropolitan water works ; and upon such recording the ponds, works, lands, waters, easements, rights and other property described in said description shall be taken for the Commonwealth. Said board, upon entering upon any land for the purpose of using the same for carrying out any of the purposes of this act, shall sign and cause to be recorded in the registry aforesaid a statement containing a general description of the land and the purposes for which it is to be used, and the probable time for which the same is to be used, and after they have taken any property under the

right of eminent domain shall notify the owner thereof, and on the request of the owner within three years after such taking shall, within thirty days after such request, furnish him with a plan or description in writing, of his land or other property so taken.

To notify owner of taking by eminent domain.

To furnish plan, etc., to owner on request.

RESERVOIRS.

SECTION 6. Said board shall forthwith, after taking the waters of said Nashua river, construct a storage reservoir upon said Nashua river above said dam of the Lancaster Mills; shall forthwith construct the reservoir in Southborough already partially constructed by the city of Boston, and the dams thereof, and assume and carry out the agreement made by said city with the town of Southborough, and all contracts made by said city relating to the building of said reservoir; may construct other reservoirs, and may raise the level of any pond or reservoir under their charge. Said board may, as they deem desirable in constructing, or raising the level of, any pond or reservoir, raise or alter or discontinue parts of any railroad or public ways, and in case of a railroad shall make such raisings or alterations of the railroad, or construct upon existing or other locations, parts of the railroad to take the place of the parts so discontinued, as, and in such manner as, shall be mutually agreed upon by said water board and the board of directors of the railroad company; and if they cannot agree thereon then as, and in such manner as, shall be determined on the application of either party, in writing, by the board of railroad commissioners of this Commonwealth, who are hereby authorized and directed to adjudicate finally upon the same; and if said water board shall be of the opinion that the making of any such change of grade, alteration or construction requires that lands be taken therefor, said board shall, in the name of the Commonwealth, take such lands and convey the same to the railroad company to be thereafter held and used as the board of directors of such company may determine, and the railroad company may if it desires locate its lines over any lands so conveyed to it, and when said new lines of railroad are completed the railroad company may discontinue the operation of the portions of its existing lines for which the new lines are substituted, and may maintain and operate said new lines of railroad; and said water board shall build the dam of any pond or reservoir constructed, or whose level is raised, as aforesaid, and

Reservoir above dam at Lancaster Mills.

Shall construct reservoir at Southborough and carry out agreements.

May construct other reservoirs.

May alter or discontinue parts of railroads or ways.

Railroad to be constructed as agreed upon.

If cannot agree, application to be made to railroad commissioners.

Railroad commissioners' adjudication to be final.

May take lands and convey same to railroad company.

Railroad company may discontinue portions of existing lines and maintain and operate new lines.

Shall build ways in place of those discontinued.

Ways to be agreed upon by board and county commissioners.

If cannot agree, application to be made to highway commission.

To conform to requirements of boards of health in flooding burial grounds.

make the raisings or alterations of the public ways as aforesaid, and build in place of the parts of public ways discontinued, as aforesaid, such other reasonable and suitable ways, which shall thereafter be highways, as, and in such manner as, shall be mutually agreed upon by said water board and the county commissioners of the county in which such dam is to be built; or if they cannot agree thereon then as, and in such manner as, shall be determined on the application of said board, in writing, by the highway commission of this Commonwealth, which commission is hereby authorized and directed to adjudicate finally upon the same. Said water board, in flooding or otherwise affecting any burial ground, shall conform to any reasonable requirements relating thereto of the board of health of the city or town in which the same is situated.

CHESTNUT HILL RESERVOIR.

To connect pumping station at Chestnut Hill reservoir with main water pipes.

Contracts of Boston with Somerville, Chelsea and Everett shall be cancelled.

To connect Nashua river with reservoir at Southborough.

SECTION 7. Said water board shall forthwith lay pipes to connect the pumping station at Chestnut Hill reservoir with the main water pipes through which water is now supplied to the cities of Somerville, Chelsea and Everett, and the Charlestown district of the city of Boston, and with Spot pond, and on the first day of January in the year eighteen hundred and ninety-eight the contracts of the city of Boston with the cities of Somerville, Chelsea and Everett, described in, and confirmed by, chapter three hundred and fifty-one of the acts of the year eighteen hundred and eighty-six, for a supply of water, shall be cancelled. Said board shall also forthwith, after taking the waters of Nashua river as aforesaid, connect said river with the tributaries of said reservoir in Southborough.

DELIVERY OF WATER TO LANCASTER MILLS.

At least 1,000,000 gallons of water to be delivered each week day.

To conform to request in writing of owner of mills.

SECTION 8. Said board, until they shall have completed the dam of said proposed reservoir on the Nashua river, and rebuilt the dam of said Lancaster Mills, shall, unless otherwise agreed by said board and the owner of said mills, deliver each week day at, and at the level of, the present top of the dam of said mills at least one million gallons of the water of said river, unpolluted by any acts or doings of said board, conforming in the delivery of said quantity, so far as practicable, to any reasonable request in writing of the owner of said mills.

CONSTRUCTION OF BUILDINGS, ROADS, ETC.

SECTION 9. Said board in carrying out the powers and duties hereinbefore conferred upon them may construct and maintain buildings, machinery, roads, conduits and aqueducts; may lay and maintain pipes, drains and wires; may alter or change the grades or directions of any water course; may carry and conduct any aqueduct, conduit, pipe, drain or wire under or over any water course, or any railroad, street or other way, in such a manner as not unnecessarily to obstruct or impede travel thereon; may dig up any such road, street or way, and lay, maintain and repair aqueducts, conduits, pipes, wires and other works beneath the surface thereof, conforming to any reasonable regulations made by the mayor and aldermen of cities and the selectmen of towns, respectively, wherein such works are performed, and restoring, so far as practicable, any such road, street or way, to as good order and condition as the same was in when such digging was commenced; said board may enter upon and use the lands of others; may take down dams to such an extent as they may deem necessary for prosecuting their works, and shall rebuild such dams whenever the necessity for keeping them down ceases; shall use such lands and do all work relating to such dams, in a reasonable manner with regard to the interests of the owners thereof, and, so far as practicable, shall heed all reasonable requests made by such owners; and in general may do any other act or thing necessary or proper for carrying out the powers and duties conferred upon them by this act.

May construct and maintain buildings, and lay and maintain pipes, etc.

May carry aqueduct, etc., over water courses, railroads, streets or ways.

May dig up roads, and lay pipes beneath surface conforming to regulations of aldermen and selectmen.

To restore roads after digging up same.

May use lands of others.

May take down and rebuild dams.

To heed requests made by owners of lands and dams.

In general to do all things necessary.

OPERATION OF WORKS TAKEN FROM BOSTON.

SECTION 10. Said board, on or before the first day of January in the year eighteen hundred and ninety-eight, shall commence the operation of the works taken by them from the city of Boston, and shall thereafter keep the same and all water works constructed by them, and all bridges which they may build across said reservoir upon the Nashua river, and (until they abandon the same by notice in writing to said city) said Chestnut Hill reservoir, safe, and shall have charge of, use, maintain and operate the same, and the Commonwealth shall exclusively be responsible for all damages caused thereby or by any defect or want of repair therein; said board shall have

To commence operation on or before January 1, 1898.

To keep works and reservoirs safe and have charge of same.

Commonwealth responsible for damages.

To have exclusive control of ponds and reservoirs.

May inspect works and fixtures in cities and towns supplied by board. May determine amount of water used and wasted.

the exclusive right and control over all ponds and reservoirs used by them in supplying water, and may order all persons to keep from entering in, upon or over, the waters thereof and the lands of the Commonwealth, city or town, surrounding the same; may inspect the water works and fixtures in any city or town supplied wholly or in part from the works under their charge, and may take all proper measures to determine the amount of water used and wasted and to prevent the improper use or waste of water.

PURCHASE AND SALE OF PROPERTY.

Storing, pumping or furnishing water.

City, town or company may sell and board purchase property.

Board may sell and lease property.

Proceeds paid into treasury of the Commonwealth.

SECTION 11. Said board and any city, town or water company aforesaid, may agree with each other for the storing or pumping of water, or the furnishing of the same as aforesaid by either party to any city, town or company; and any such city, town or company may sell to said board, and said board may purchase any property of such city, town or company, whether taken by eminent domain or otherwise, that said board may deem desirable for use in furnishing, as aforesaid, water to any city, town or water company; and said board may sell at public or private sale any property, real or personal, whether taken by eminent domain or otherwise, no longer needed for the water works under their charge, or may from time to time lease any property not then so needed. The proceeds from the operations of said board shall be paid into the treasury of the Commonwealth.

EXPENSES AND DAMAGES.

Board shall incur expense.

May agree upon amount of damages.

Damages of town of Clinton.

Damages of persons or corporations by taking of property, change of grade, etc.

SECTION 12. Said board shall incur such expenses as they deem necessary in constructing, operating and maintaining the water works under their charge; may agree with the party injured, upon the damages sustained by any city or town by the taking or use of its lands, ponds, reservoirs, water sources, aqueducts or other property, or the cancellation of contracts, as aforesaid; the damages sustained by the town of Clinton by any interference with its sewerage system or with its drainage rights or privileges; the damages sustained by any person or railroad or other corporation in property by any taking of property or by any change of grade, alteration or discontinuance of any railroad or public way, or by the construction or maintenance of any reservoir or other work, or by the interference with the use of any water, or by any other act or thing

done by said board under this act; shall save harmless the several cities and towns within which any road, street or way is dug up as aforesaid, against all damages for injuries resulting from a defect or want of repair in any road, street or way, caused by such digging up, or by constructing, laying, maintaining or repairing any aqueduct, conduit, pipe, wire or other works therein, and shall furnish without charge to all towns within which any work is done under authority of this act such additional police protection as may be necessary in consequence thereof: *provided*, said board shall have due and reasonable notice of the claims for such damages and opportunity to make a legal defence thereto.

Shall save cities and towns harmless against damages resulting from defect in ways caused by digging up same or laying pipes, etc., thereon.
Shall furnish police protection to towns.

Proviso.
Board to have notice of claims and opportunity to defend same.

PETITION FOR JURY.

SECTION 13. Said board, city, town, person or corporation, if they cannot agree upon any damages, sustained as aforesaid, may, except in the cases in which payment is otherwise provided for in this act, within two years after the day of the taking of any land, water, easements or other property, or of the use of any property, or of the making of any change of grade, alteration, discontinuance, or location of a way or railroad, or of the doing of any other act or thing causing the damage, file in the office of the clerk of the superior court for the county in which the property taken, used or affected in value by such taking or other act of said board is situated, a petition, signed by the petitioner or the attorney of the petitioner, for a jury to determine such damages, and thereupon, after such notice as said court shall order, the damages so sustained shall be determined by a jury in said court, in the same manner as damages for lands taken for highways are determined. In determining any damages caused by any change of grade or discontinuance of a public way or railroad, or the substitution of a part of a public way or railroad for another part, there shall be taken into account any benefit to the party injured received from this act and anything done thereunder. Interest shall be included in such damages from the date of the taking, or the doing of the act or thing causing the damages, and costs shall be taxed and execution issued as in civil cases, against the Commonwealth in case the petitioner prevails, and against the petitioner in case he does not prevail. Damages for the temporary use of or injury to property may, on the request of the

If cannot agree upon amount of damages, jury may be had if applied for within two years.

Application to be filed in office of clerk of superior court.

After notice, damages to be determined by jury.

Benefit to be taken into account in determining damages.

Interest shall be allowed from date of taking, etc., and costs to be taxed.

Damages for temporary use may be assessed

by monthly
payments.

petitioner, be assessed by monthly payments, to be continued so long as the property is used.

COMMISSIONS MAY BE APPOINTED TO DETERMINE DAMAGES.

Board may agree with owners of certain real estate not owned, April 1, 1885, by the owner of the Lancaster Mills, as to damages, etc.

SECTION 14. Said board, upon the application of the owner of any real estate taken for said proposed reservoir upon the Nashua river, or the owner of any real estate entered upon and used, or of any real estate injured by the taking of the waters of said Nashua river, whether said real estate is within or without the Commonwealth, or of any real estate not taken but directly or indirectly decreased in value by this act or the doings of said board thereunder, situated in the town of West Boylston or in that part of the town of Boylston on the northerly side of said proposed reservoir, or in that part of the town of Clinton on either side of River or Grove streets, between the dam of said proposed reservoir and a line drawn from the northerly corner of Oak and Boylston streets to the northerly corner of said Grove and Nashua streets, and not owned on the first day of April in the year eighteen hundred and ninety-five, by the owner of the Lancaster Mills, may agree with such owner upon the damages to be paid for such taking, injury or decrease in value, and if said board and the owner of any such real estate cannot agree upon such damages, such owner may, within two years after the first taking of water, or of land for said reservoir, under the right of eminent domain, file in the clerk's office of the supreme judicial court for the county of Worcester, in term time or vacation, a petition for the determination of such damages, and thereupon said court, after notice by publication in some newspaper published in the county of Worcester, and in such other manner as the court may order, that all persons entitled to file such petitions will be heard by said court on a day therein named, and a hearing thereon; shall from time to time appoint one or more commissions, each consisting of three disinterested persons, and may after notice and hearing fill any vacancy occurring in any such commission until all petitions referred to it have been heard and determined. Each of said commissions shall, after notice and hearing, determine the damages specified in all such petitions as may be filed as aforesaid and referred to it by said court; and if the owner of any such real estate, no part of

If they cannot agree, petition may be brought within two years in supreme judicial court for county of Worcester.

After notice and hearing court to appoint commission of three persons. Court may fill vacancies in commissions. Commissions shall determine damages, specified in petitions.

which is taken but which is decreased in value, shall in the petition aforesaid signify his willingness to surrender the real estate, or if there is a mill thereon, the real estate and machinery thereon, to the Commonwealth, the commission shall also determine the value of such real estate, or real estate and machinery, and interest may be included in such damages and in such value at such rate and for such time as the commission may deem just and equitable. Said commissions shall determine the damage to and value of real estate, machinery and business, and from time to time report their determinations on the petitions of such owners to said court. In case any individual or firm owning on the first day of April in the year eighteen hundred and ninety-five an established business on land in the town of West Boylston, whether the same shall be taken or not under this act, or the heirs or personal representatives of such individual or firm, shall deem that such business is decreased in value by the carrying out of this act, whether by loss of custom or otherwise, and unable to agree with said board as to the amount of damages to be paid for such injury, such damages shall be determined and paid in the manner hereinbefore provided. The words "real estate" as used in this section shall include water rights, and in the case of mills all machinery thereon.

Interest may be included in damages.

Commissions to report to said court.

Established business in West Boylston if decreased in value shall have damages determined.

Real estate to include water rights and machinery.

[Compensation for damages to property and business in Sterling. Acts 1897. Chap. 445.]

PAYMENT OF DAMAGES.

SECTION 15. Said board shall, upon agreeing upon any damages, or upon the acceptance by said court of any determination specified in the preceding section notify the owner that they will pay the damages, or, in case the petitioner offers to make surrender, if they so prefer, they will pay the value so agreed upon or determined, and if any such owner shall in accordance with such notice and within one year after being so notified, deliver a release of such damages or a deed of the real estate, to and satisfactory to, said water board, said water board shall certify to the treasurer of the Commonwealth the amount to be paid such owner, and said treasurer shall pay the same from the proceeds of the bonds hereinafter provided for. Said water board, or any persons whose property is taken under the right of eminent domain, or entered upon or injured by the taking of said water, if dissatisfied with any determination of damages made by any commission, may at the term on which such determination is filed in court, or at the succeeding

Board to notify owner that they will pay damages or value agreed upon or determined.

If owner releases damages or gives deed within one year he shall be paid from treasury of Commonwealth.

If board or owner dissatisfied with award of commission, may claim trial by jury.

term, claim a trial by jury to determine such damages, and thereupon the damages shall be determined by a jury in said supreme judicial court as provided in section thirteen of this act.

PAYMENT TO CITY OF BOSTON AND TOWNS OF BOYLSTON AND WEST BOYLSTON.

Boston to be reimbursed for moneys paid in connection with basins not yet built.

Boylston to be paid \$2,000 a year.

West Boylston to be paid \$12,000 a year.

No tax or other payment to be made.

SECTION 16. The treasurer of the Commonwealth shall, from the proceeds of the bonds hereinafter provided for, reimburse the city of Boston for all moneys paid or that may hereafter be paid by said city for land damages, or otherwise, in connection with the location, building or maintenance of reservoirs or basins not yet built, or for lands taken for the preservation or protection of the purity of the waters of any reservoirs, or basins or of the tributaries thereof, and shall pay as part of the expenses of said metropolitan water works to the town of Boylston the sum of two thousand dollars a year and to the town of West Boylston the sum of twelve thousand dollars a year for the year of and each year succeeding said taking of the waters of said Nashua river, so long as each of said towns remains a municipality, and shall pay no tax or other payment to either of said towns on account of any property held by said water board for the purposes of a water supply.

[Annual payment to Boylston increased to \$3,000. Acts 1896. Chap. 436.]

[Compensation to Boylston and West Boylston in lieu of taxes. Acts 1897. Chap. 467.]

[Compensation allowed to employés in West Boylston. Acts 1896. Chap. 450.]

METROPOLITAN WATER LOAN.

Negotiable bonds to be issued not exceeding \$27,000,000.

Principal and interest payable in gold coin.

Payable in not less than thirty nor more than forty years from date. Interest not to exceed four per cent.

SECTION 17. The treasurer and receiver general shall, from time to time, on the request of said board, issue negotiable bonds in the name and behalf of the Commonwealth, and under its seal, to an amount not exceeding twenty-seven million dollars, designated on the face thereof, Metropolitan Water Loan. Said bonds shall be deemed a pledge of the faith and credit of the Commonwealth, shall be countersigned by the governor; shall have the principal and interest made payable thereon, in gold coin of the United States of America or its equivalent; shall bear interest payable semi-annually on the first days of January and July of each year; shall be registered, or with interest coupons attached; shall be payable within such terms not less than thirty nor more than forty years, and shall bear such rates of interest not exceeding four per cent. per annum, and be issued and disposed of in such amounts and in such modes and at such times and prices as the treasurer and receiver general, with the approval of the governor, shall from

time to time determine. Said treasurer shall, on issuing any of said bonds, establish a sinking fund and determine the amount to be paid thereto each year, sufficient with its accumulations to extinguish the debt at maturity.

Sinking fund to be established.

PROCEEDS FROM SALES OF PROPERTY AND BONDS.

SECTION 18. Said treasurer shall apply the proceeds from the sales of property made as hereinbefore provided, and the proceeds from the sales of said bonds, exclusive of the amounts received from premiums, to the payments for the property taken by said board, the payment of the damages aforesaid, and the payment of the expenses of construction of said water works, and the other payments specified in this act, and shall apply any premiums received from sales of said bonds, any assessments hereinafter provided for paid by the cities and towns, and the proceeds from the operations of said board, exclusive of the proceeds from sales of property, to the payment of the interest, sinking fund requirements and expenses of maintenance and operation of said water works, and shall take the balance required for said payments, if any, from the proceeds of said bonds, and shall apply the surplus, if any, to the payment of said interest, sinking fund requirements and expenses, for the following year. Said treasurer shall advance to such person as shall have been designated by said water board and shall have given a bond with sufficient sureties, to be approved by the auditor of the Commonwealth, in the sum of ten thousand dollars, such sums, not exceeding ten thousand dollars at any time, as said auditor may certify to be necessary to enable said board to make direct payment upon the pay rolls and other accounts of said board, and such persons shall, as soon as may be after expending any sum so advanced, and in all cases within thirty days from the receipt of any such sum, file with the auditor a statement in detail of the moneys expended subsequent to the last previous accounting, approved by said water board, and where it is practicable to obtain them, also file receipts or other like vouchers of the persons to whom the payments have been made.

Application of proceeds from sales of property and bonds.

Applications of amounts received from premiums and assessments.

Application of surplus.

\$10,000 to be advanced to person designated by board.

Detailed statement of moneys expended to be filed, also receipts and vouchers of persons receiving same.

ESTIMATE AND APPORTIONMENT OF ANNUAL EXPENSES.

SECTION 19. Said treasurer shall in each year estimate the amount, in addition to the premiums from sales of said bonds and the proceeds from the operations of said board, exclusive

Treasurer to estimate annually amount required for

Maintenance,
interest, etc.,
and apportion
same in propor-
tion to valuation
and population.

One sixth only
of valuation and
population in
certain cities
and towns.

Cities and
towns assessed
upon full
valuation and
population
furnishing part
of water supply
to be allowed
certain sums.

First apportion-
ment to be
made in 1898.

Cities and
towns to be
notified of
assessments.

To be paid as
part of state tax.

of the proceeds from sales of property, required during the year to pay the interest, sinking fund requirements, expenses of maintenance and operation of said water works, and shall apportion to the city of Boston the proportion of such amount that the valuation of said city for the preceding year bears to the total of all such valuations of all cities and towns in said water district: *provided, however*, there shall be included only one sixth of the total valuation of any such city and town which has not reached the safe capacity of its present sources of supply in a dry year, as determined by said water board and certified to said treasurer, and has not made application to said board for water, and the remainder to the other cities and towns in said district, one third in proportion to their respective valuations and the remaining two thirds in proportion to their respective populations, including however only one sixth of the total valuation and one sixth of the total population of any such city and town which has not reached the safe capacity of its sources or of the sources of supply of the water company by which a town is supplied, or has not made application for water as aforesaid; and *provided, further*, that any city or town assessed upon its full valuation and population, which furnishes a part of its water supply from its own works or receives a supply from a water company, shall be allowed and credited in its apportionment with a sum equal to twelve dollars for each million gallons of water furnished as aforesaid, as determined by said water board and certified to said treasurer, and *provided, further*, that no such amount shall be so apportioned until the year eighteen hundred and ninety-eight, and in said year only the amount of three hundred thousand dollars shall be apportioned, and the sums of money expended by the state board of health under chapter four hundred and fifty-nine of the acts of the year eighteen hundred and ninety-three and chapter four of the resolves of the year eighteen hundred and ninety-five, and in the succeeding years the said amount of three hundred thousand dollars and two hundred thousand dollars additional for each year thereafter shall be so apportioned until the entire amount required as aforesaid is reached, and thereafter such entire amount shall be so apportioned. Said treasurer shall in each year notify each city and town of the amount of its assessment, and the same shall be paid by the city or town into the treasury of the Commonwealth at the time required for the payment and as part of its state tax.

CONTROL AND DISTRIBUTION OF WATER.

SECTION 20. The water board, water commissioners or superintendent of any city or town in the metropolitan water district, shall for their respective cities or towns, on and after the first day of January in the year eighteen hundred and ninety-five, have the charge and control of the water sources, water and water works owned and used by said city or town and not taken or used by said metropolitan water board as herein provided. Said water board, water commissioners or superintendent shall distribute and control the use of the water so furnished, and apply meters and extend the pipes and other work as said water board, water commissioners or superintendent may deem expedient; shall keep the pipes, fixtures and other works under their charge in good condition and repair, but shall not expend in any year more than the amount appropriated by the city or town therefor. Said water board, water commissioners or superintendent, with the approval of the mayor or selectmen, shall determine the rate to be paid for water by the owner of the premises to which the water is furnished, or by the person or persons using the water: *provided, however*, that the minimum rates to be paid for water, and the premises to which the high service supply shall be furnished, shall be subject to the approval of said metropolitan water board. Any water board, water commissioner or superintendent as aforesaid shall for the water works under his charge do all the acts and things relating to buildings, machinery, roads, conduits, aqueducts, pipes and drains, which said metropolitan water board is authorized to do for the water works under their charge, and may take lands therefor, in fee or otherwise, and shall do all such acts and things and make all such takings in the manner in which said metropolitan water board are authorized to do similar things, and the damages sustained shall be recovered of, and paid by, the city or town for which such water board, water commissioners or superintendents are appointed or elected, in the same manner as damages caused by similar acts of said metropolitan water board are recovered of, and paid by, the Commonwealth.

Water boards, etc., of cities and towns to have charge of works not taken by board.

Not to exceed appropriations by city or town.

Water rates to be determined.

Board to approve rates.

Water boards, etc., of cities and towns to do all things relating to water supply.

Damages shall be paid by city or town.

APPLICATION OF INCOME.

SECTION 21. The income received in each city or town from the water works under the charge of its water board, water

Cities and towns to apply income to

payment of
expenses,
interest, etc.

commissioners or superintendent, shall be applied to the payment of the expenses of maintenance and operation incurred by said water board, water commissioners or superintendent; the interest and sinking fund requirements of all bonds, notes or scrip of the city or town issued on account of the water works of such city or town; the assessment of the city or town to be paid to the treasurer of the Commonwealth as hereinbefore provided; the expenses of the extension of the works; and the balance, if any, as the city or town may determine. If such income in any year shall not be sufficient for said payments the balance required therefor shall be raised by taxation or by loan, as the city or town may determine; and the city or town is hereby authorized to assess such taxes and make such loans without further authority from the legislature.

Balance as city
or town may
determine.

If income is
insufficient
balance to be
raised by
taxation or
loan.

WORCESTER AND CERTAIN TOWNS MAY TAKE WATER.

City of
Worcester and
certain towns
may take water
from Nashua
river under
certain con-
ditions.

SECTION 22. The towns of Clinton, Sterling, Boylston, West Boylston, Lancaster, Holden, Rutland, Princeton, Paxton and Leicester, and the city of Worcester, may take from the south branch of the Nashua river, above the dam of the proposed reservoir on said river, so much of the water thereof as they have already been or may hereafter be authorized by the legislature to take, for supplying their inhabitants with water, and in case either of the towns of Lancaster, Holden, Rutland, Princeton, Paxton or Leicester, or the city of Worcester, shall so take water, it shall pay to the Commonwealth, to be paid into the sinking funds for said bonds, a fair proportion of the cost incurred by the Commonwealth for said water and for the construction, maintenance and operation of said works, the same to be determined by the engineer of said board and an engineer to be appointed by the city or town, and if they cannot agree, the proportion shall be determined by a master to be appointed by the supreme judicial court on the petition of either party interested, and the report of such master made and accepted by said court shall be final and binding on all parties.

If water is
taken, propor-
tion of cost to
be paid to the
Common-
wealth.

If cannot agree
on amount,
master to be
appointed.

[Compensation for water if taken by certain towns regulated by point of taking. Acts 1897. Chap. 456.]

USE OF WATER IN DISTRICT RESTRICTED.

No city or town
in district to use
water for
domestic
purposes except

SECTION 23. No city or town, any part of which is within ten miles of the state house, or any water company owning a water pipe system in any such city or town shall, except in case

of emergency, use. for domestic purposes, water from any source not now used by it except as herein provided or as shall be hereafter authorized by the legislature. If any town or towns in said district shall take the franchise, works and property in such town or towns, of any water company, the compensation to be allowed and paid therefor shall not be increased or decreased by reason of the provisions of this act. No town in said water district now supplied with water by a water company owning the water pipe system in such town, shall introduce water from the metropolitan water works until it shall first have acquired the works of such company.

when authorized by legislature.

No town to introduce water from metropolitan supply till works of water company have been acquired.

[Towns may petition court to regulate water rates charged by water companies. Acts 1897. Chap. 336.]

[Stoneham may introduce water from metropolitan water works before acquiring the works of water company. Acts 1897. Chap. 473.]

SANITARY PROTECTION OF WATER.

SECTION 24. The state board of health is hereby authorized and required to make rules and regulations for the sanitary protection of all waters used by the metropolitan water board for the water supply of any city, town or water company aforesaid, and to transfer and deliver to said water board, such plans, maps and other information in their possession as will assist said board in carrying out the provisions of this act.

Rules for protection of water used by board.

Plans, maps and other information to be transferred to board.

IMPROPER USE OF WATER PROHIBITED.

SECTION 25. No person shall take or divert any water of a water supply of any city or town in said water district from any water source, reservoir, conduit or pipe used for supplying such water to, or in any such city or town, or occupy, injure or interfere with any such water, or with any land, building, aqueduct, pipe, drain, conduit, hydrant, machinery or other work or property so used, and no person shall corrupt, render impure, waste or improperly use, any such water.

Water not to be diverted.

Buildings, machinery, etc., not to be injured.

PRECEDING SECTION NOT TO APPLY IN CERTAIN CASES.

SECTION 26. The provisions of the preceding section shall not apply to any person in taking or diverting any such water or interfering with or occupying any water, land or works therein described, by permission of said metropolitan water board, or the water board, water commissioners or superintendent of any city or town having charge of the land, water or

Not to apply where water, land, etc., are taken or occupied by permission of board.

Nor to inhabitants of any city or town taking water for ordinary uses.

work; nor to the individual inhabitants of any city or town within the watershed of any water supply used by said metropolitan water board, or by any city or town aforesaid, in taking from the part of the supply or from the tributaries of the supply within their respective city or town limits so much of the water thereof as they shall need for their ordinary domestic household purposes, for extinguishing fires, or for generating steam.

ENFORCEMENT.

Board to enforce act and rules, etc., made thereunder.

SECTION 27. Said metropolitan water board, and their employees designated for the purpose, shall enforce the provisions of this act, and of the rules, regulations and orders made thereunder, and may enter into any building, and upon any land for the purpose of ascertaining whether sources of pollution there exist, and whether the provisions of this act and of the rules, regulations and orders made as aforesaid are complied with; and, where the enforcement of any such provisions, rules, regulations or orders will require public works for the removal or purification of sewage, said metropolitan water board shall not enforce the same until they have provided such works, and the amount paid therefor shall be considered as part of the expenses of construction of the metropolitan water works, and such works shall be maintained and operated as a part of said water works.

May enter upon land for that purpose.

Act not to be enforced until sewage is provided for.

Sewage works to be operated as part of water works.

JURISDICTION OF THE COURTS.

Supreme judicial and superior courts have jurisdiction in equity to enforce provisions of act.

SECTION 28. The supreme judicial court or any justice thereof, and the superior court or any justice thereof, shall, in term time or vacation, on the petition of said board or any city, town, corporation or person interested, or of the attorney of any such petitioner, have jurisdiction in equity or otherwise to enforce the provisions of this act, and of any rule, regulation or order made under the authority of this act, and to prevent any violation of said provisions, rules, regulations or orders.

PENALTIES.

To be punished by fine or imprisonment, or both.

SECTION 29. Whoever shall do any of the acts herein prohibited, or shall violate or refuse to comply with any rule, regulation or order made under the authority of this act shall, on complaint or indictment therefor and conviction thereof, be punished for each offence by a fine not exceeding five hundred

dollars, to be paid to the Commonwealth, or by imprisonment not exceeding one year in the house of correction, or by both such fine and imprisonment.

GENERAL LAWS.

SECTION 30. All general laws relating to the water supplies of cities and towns or the lands and other property used for such supplies shall, so far as they are not inconsistent with the provisions of this act, apply to and be observed in carrying out the purposes of this act. General laws to be observed.

[Application extended to St. 1893, 352; Boylston and West Boylston excepted. Acts 1897. Chap. 327.]

CONSTRUCTION OF WORKS.

SECTION 31. In the construction of these works preference in employment shall be given to citizens of this Commonwealth. Preference to be given to citizens.

SECTION 32. This act shall take effect upon its passage.
[Approved June 5, 1895.]

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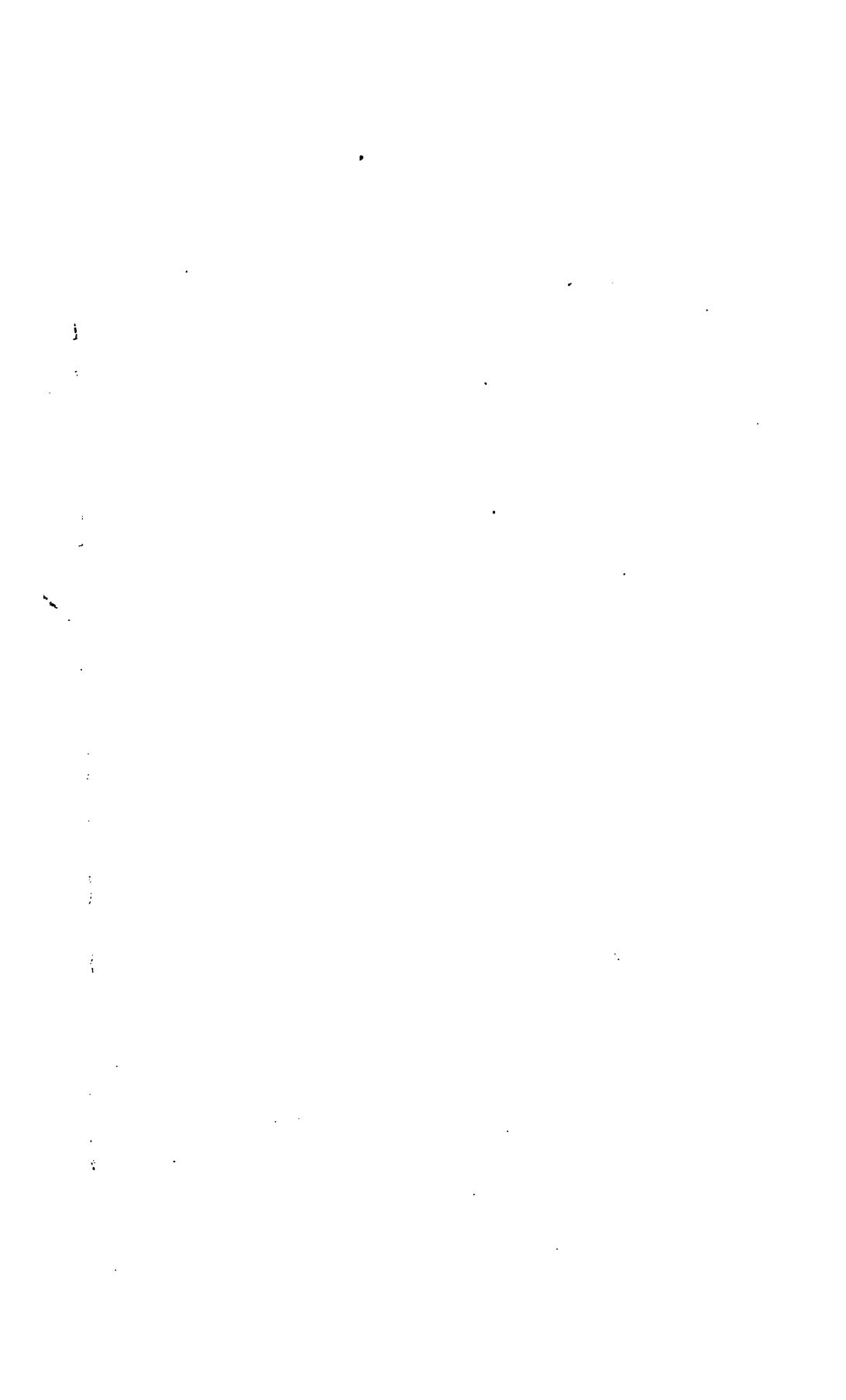
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APPENDIX No. 5.

LEGISLATION SUBSEQUENT TO METROPOLITAN WATER ACT.

[Chapter 436 of the Acts of the Year 1896.]

AN ACT RELATIVE TO THE COMPENSATION FOR DAMAGES OCCASIONED BY THE CONSTRUCTION OF THE METROPOLITAN WATER SYSTEM.

Be it enacted, etc., as follows:

SECTION 1. Section sixteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five is hereby amended by striking out in the eleventh line, the word "two", and inserting in place thereof the word:

1895, 488, § 16,
amended.

—three,— so as to read as follows:— *Section 16.* The treasurer of the Commonwealth shall, from the proceeds of the bonds hereinafter provided for, reimburse the city of Boston for all moneys paid or that may hereafter be paid by said city for land damages, or otherwise, in connection with the location, building or maintenance of reservoirs or basins not yet built, or for lands taken for the preservation or protection of the purity of the waters of any reservoirs, or basins or of the tributaries thereof, and shall pay as part of the expenses of said metropolitan water works to the town of Boylston the sum of three thousand dollars a year and to the town of West Boylston the sum of twelve thousand dollars a year for the year of and each year succeeding said taking of the waters of said Nashua river, so long as each of said towns remains a municipality, and shall pay no tax or other payment to either of said towns on account of any property held by said water board for the purposes of a water supply.

City of Boston
to be reim-
bursed and
certain sums to
be paid to towns
of Boylston and
West Boylston.

SECTION 2. This act shall take effect upon its passage.
[Approved May 27, 1896.]

[Chapter 450 of the Acts of the Year 1896.]

AN ACT RELATIVE TO THE COMPENSATION OF EMPLOYEES IN WEST BOYLSTON.

Be it enacted, etc., as follows:

SECTION 1. Any resident of the town of West Boylston employed by any corporation, partnership or individual at the

Certain persons
deprived of
employment in

West Boylston
may file claim
for damages.

time when the plant of such corporation, partnership or individual is taken, and work therein stopped, on account of a reservoir for the metropolitan water supply, and who is obliged by reason of such taking to seek employment elsewhere, shall have the right for one year from the termination of such employment as aforesaid to file a claim for damages with the metropolitan water commission, and if the same is not settled within sixty days from the filing thereof, he may bring a bill in equity in the superior court for the county of Worcester for the adjudication and collection of such damage. Any number of persons deprived of employment as aforesaid may unite in such bill, and the withdrawal of any shall not prejudice the rights of others.

Court to ascer-
tain certain
facts, etc.

SECTION 2. It shall be the duty of the court to ascertain whether or not such claimants have resided and been employed and deprived of employment as specified in this act, and if so to issue a decree in favor of each to recover the actual damage which he has suffered by reason of such loss of employment, not however to exceed the sum of his wages for six months at the rate of wages paid to him for the last six months prior to such suspension of employment.

Certain em-
ployees not
entitled to
receive
compensation.

SECTION 3. No person shall be entitled to receive compensation under this act unless he shall have been employed in the town of West Boylston continuously from the date when chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, entitled "An Act to provide for a metropolitan water supply", became a law, up to the date of the taking of the property wherein said person is employed.

Stockholders
not entitled
to receive
compensation.

SECTION 4. No stockholder of any corporation whose plant is taken on account of a reservoir for said metropolitan water supply shall be entitled to receive compensation under this act.

SECTION 5. This act shall take effect upon its passage.
[Approved May 28, 1896.]

[Chapter 327 of the Acts of the Year 1897.]

AN ACT RELATIVE TO PROPERTY HELD BY THE METROPOLITAN
WATER BOARD.

Be it enacted, etc., as follows :

1896, 486, § 30,
amended.

SECTION 1. Section thirty of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and

ninety-five is hereby amended by striking out the whole of said section and inserting in place thereof the following:—*Section 30.* All general laws relating to the water supplies of cities and towns, and property held for such supplies, including chapter three hundred and fifty-two of the acts of the year eighteen hundred and ninety-three, shall, so far as they are applicable and not inconsistent with the provisions of this act, apply to the metropolitan water supply and the lands held and used by the metropolitan water board for said water supply, in cities and towns other than the towns of Boylston and West Boylston.

Certain general laws to apply to metropolitan water supply, etc.

SECTION 2. This act shall take effect upon its passage.
[Approved April 29, 1897.]

[Chapter 336 of the Acts of the Year 1897.]

AN ACT TO REGULATE THE PRICE TO BE CHARGED FOR WATER BY
WATER COMPANIES IN THE METROPOLITAN DISTRICT.

Be it enacted, etc., as follows:

SECTION 1. Section twenty-three of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five is hereby amended by adding at the end thereof the words:—and no such company shall be entitled to charge more for water than a reasonable sum, measured by the price ordinarily charged for a similar service in other cities and towns in the metropolitan district. The selectmen of a town or any persons deeming themselves aggrieved by the price charged for water by any such company may, in the year eighteen hundred and ninety-eight and every fifth year thereafter, apply by petition to the supreme judicial court, asking to have the rate fixed at a reasonable sum, measured by the standard above-specified; and two or more judges of said court, after hearing the parties, shall establish such maximum rates as said court shall deem proper; and said maximum rates shall be binding upon said water company until the same shall be revised or altered by said court pursuant to this act,—so as to read as follows:—

1896, 488, § 23,
amended.

Section 23. No city or town, any part of which is within ten miles of the state house, or any water company owning a water pipe system in any such city or town shall, except in case of emergency, use, for domestic purposes water from any source not now used by it except as herein provided or as shall be

Use of water by certain cities, towns and water companies restricted, etc.

hereafter authorized by the legislature. If any town or towns in said district shall take the franchise, works and property in such town or towns, of any water company, the compensation to be allowed and paid therefor shall not be increased or decreased by reason of the provisions of this act. No town in said water district now supplied with water by a water company owning the water pipe system in such town, shall introduce water from the metropolitan water works until it shall first have acquired the works of such company; and no such company shall be entitled to charge more for water than a reasonable sum, measured by the price ordinarily charged for a similar service in other cities and towns in the metropolitan district. The selectmen of a town or any persons deeming themselves aggrieved by the price charged for water by any such company may, in the year eighteen hundred and ninety-eight and every fifth year thereafter, apply by petition to the supreme judicial court, asking to have the rate fixed at a reasonable sum, measured by the standard above-specified; and two or more judges of said court, after hearing the parties, shall establish such maximum rates as said court shall deem proper; and said maximum rates shall be binding upon said water company until the same shall be revised or altered by said court pursuant to this act.

SECTION 2. This act shall take effect upon its passage.
[Approved May 1, 1897.]

[Chapter 339 of the Acts of the Year 1897.]

AN ACT TO REQUIRE BONDS TO BE GIVEN UNDER CERTAIN CONTRACTS MADE BY THE METROPOLITAN WATER BOARD.

Be it enacted, etc., as follows:

Bonds to be given under certain contracts made by metropolitan water board.

It shall be the duty of the metropolitan water board in making contracts for the construction of the metropolitan water works to require every employer of labor engaged in the construction of said works to give to each city or town in which such labor may be employed a bond in the penal sum of three thousand dollars, conditioned to save harmless and indemnify such city or town against any loss, expense or charges that said city or town may legally incur because of pauper or indigent employees brought to said town and having no settlement therein. *[Approved May 5, 1897.]*

[Chapter 445 of the Acts of the Year 1897.]

AN ACT RELATIVE TO THE COMPENSATION FOR DAMAGES IN THE TOWN OF STERLING OCCASIONED BY THE CONSTRUCTION OF THE METROPOLITAN WATER SYSTEM.

Be it enacted, etc., as follows:

SECTION 1. The owner of any real estate situated in that part of the town of Sterling on the southerly and westerly side of Stillwater river, not taken but directly or indirectly decreased in value by chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five entitled, "An Act to provide for a metropolitan water supply", or by the doings of the metropolitan water board thereunder, and any individual or firm owning, on the first day of April in the year eighteen hundred and ninety-five, an established business on land in said part of the town of Sterling, or the heirs or personal representatives of such individual or firm, who shall deem that such business is decreased in value, whether by loss of custom or otherwise, by the carrying out of said act to provide for a metropolitan water supply, shall have the same right to damages for such decrease in value, to be determined and recovered in the same way, as is provided for owners of real estate or of an established business in the town of West Boylston by said chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five.

Compensation for damages in the town of Sterling occasioned by construction of metropolitan water system.

SECTION 2. The treasurer of the Commonwealth shall pay hereafter as a part of the expenses of the metropolitan water works annually on or before the thirty-first day of December to the town of Sterling an amount equal to the assessment made by the assessors of the town of Sterling as of the first day of May in the year eighteen hundred and ninety-four, on all real estate taken or acquired, and held by the metropolitan water board on the first day of May in each year, under authority of said chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and acts in amendment thereof, so long as said property is held by said metropolitan water board, such payment to be in place of taxes and any other payment required by law upon such property.

Treasurer of the Commonwealth to pay to town of Sterling a certain sum annually.

SECTION 3. This act shall take effect upon its passage.
[Approved June 2, 1897.]

[Chapter 456 of the Acts of the Year 1897.]

AN ACT TO REQUIRE CERTAIN PAYMENTS BY MUNICIPALITIES TAKING WATER FROM THE SOUTH BRANCH OF THE NASHUA RIVER, IN CERTAIN CASES.

*Be it enacted, etc., as follows :*1896, 498, § 22,
amended.Taking of
certain water
by city of
Worcester and
certain towns.

Section twenty-two of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five is hereby amended by striking out in the fourteenth and fifteenth lines, the words "and for the construction, maintenance and operation of said works, the same to", and inserting in place thereof the following:— and if the water is taken from the river above said reservoir it shall pay in addition a fair proportion of the cost of maintaining the purity of said water above the point of said taking; and if the water is taken from said reservoir it shall pay in addition a fair proportion of the cost of maintaining the purity of said water and of the cost of constructing and maintaining said dam and reservoir. Said proportions shall,— so as to read as follows:— *Section 22.* The towns of Clinton, Sterling, Boylston, West Boylston, Lancaster, Holden, Rutland, Princeton, Paxton and Leicester, and the city of Worcester, may take from the south branch of the Nashua river, above the dam of the proposed reservoir on said river, so much of the water thereof as they have already been or may hereafter be authorized by the legislature to take, for supplying their inhabitants with water, and in case either of the towns of Lancaster, Holden, Rutland, Princeton, Paxton or Leicester, or the city of Worcester, shall so take water, it shall pay to the Commonwealth, to be paid into the sinking funds for said bonds, a fair proportion of the cost incurred by the Commonwealth for said water, and if the water is taken from the river above said reservoir it shall pay in addition a fair proportion of the cost of maintaining the purity of said water above the point of said taking; and if the water is taken from said reservoir it shall pay in addition a fair proportion of the cost of maintaining the purity of said water and of the cost of constructing and maintaining said dam and reservoir. Said proportion shall be determined by the engineer of said board and an engineer to be appointed by the city or town, and if they cannot agree, the proportion shall be determined by a master to be appointed by the supreme judicial court on the

petition of either party interested, and the report of such master made and accepted by said court shall be final and binding on all parties. [*Approved June 3, 1897.*]

[Chapter 467 of the Acts of the Year 1897.]

AN ACT RELATIVE TO COMPENSATION FOR LOSS OF TAXES OCCASIONED
BY THE CONSTRUCTION OF THE METROPOLITAN WATER SYSTEM.

Be it enacted, etc., as follows:

SECTION 1. Section sixteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, as amended by section one of chapter four hundred and thirty-six of the acts of the year eighteen hundred and ninety-six, is hereby amended by adding at the end thereof the following words:—*provided, however*, that the Commonwealth shall pay annually, on or before the thirty-first day of December, to the towns of West Boylston and Boylston, until such time as the payments to said towns hereinbefore set forth become due and payable, an amount equal to the assessment made by the assessors of each of said towns as of the first day of May in the year eighteen hundred and ninety-four, on all property in their towns taken or acquired on or before the first day of May in such year, under the authority of this act; and shall pay to said towns annually, on or before the thirty-first day of December, an amount equal to the assessment made as aforesaid on all real estate in their towns so taken or acquired on or before the first day of May in each year by the Commonwealth, outside the limits of said proposed reservoir, so long as the same shall remain the property of the Commonwealth; and *provided, further*, that no part of the fifty-one hundred and sixty-three acres described in the report of the state board of health on a metropolitan water supply made to the general court in the year eighteen hundred and ninety-five as necessary for said reservoir and the margin around the same shall be included in determining the amount to be paid in consequence of the taking of property outside the limits of said reservoir and margin,—so as to read as follows:—*Section 16.* The treasurer of the Commonwealth shall, from the proceeds of the bonds hereinafter provided for, reimburse the city of Boston for all moneys paid or that may hereafter be paid by said city for land damages, or otherwise, in connection with the location, building or maintenance of reservoirs or basins not yet built, or for

1895, 488, § 16,
etc., amended.

City of Boston
to be reim-
bursed and
certain sums to
be paid to
towns of
Boylston and
West Boylston.

Provisos.

lands taken for the preservation or protection of the purity of the waters of any reservoirs, or basins or of the tributaries thereof, and shall pay as part of the expenses of said metropolitan water works to the town of Boylston the sum of three thousand dollars a year and to the town of West Boylston the sum of twelve thousand dollars a year for the year of and each year succeeding said taking of the waters of said Nashua river, so long as each of said towns remains a municipality, and shall pay no tax or other payment to either of said towns on account of any property held by said water board for the purposes of a water supply: *provided, however*, that the Commonwealth shall pay annually, on or before the thirty-first day of December, to the towns of West Boylston and Boylston, until such time as the payments to said towns hereinbefore set forth become due and payable, an amount equal to the assessment made by the assessors of each of said towns as of the first day of May in the year eighteen hundred and ninety-four, on all property in their towns taken or acquired on or before the first day of May in such year, under the authority of this act; and shall pay to said towns annually, on or before the thirty-first day of December, an amount equal to the assessment made as aforesaid on all real estate in their towns so taken or acquired on or before the first day of May in each year by the Commonwealth, outside the limits of said proposed reservoir, so long as the same shall remain the property of the Commonwealth; and *provided, further*, that no part of the fifty-one hundred and sixty-three acres described in the report of the state board of health on a metropolitan water supply made to the general court in the year eighteen hundred and ninety-five as necessary for said reservoir and the margin around the same shall be included in determining the amount to be paid in consequence of the taking of property outside the limits of said reservoir and margin.

SECTION 2. This act shall take effect upon its passage.
[Approved June 5, 1897.]

[Chapter 473 of the Acts of the Year 1897.]

AN ACT TO SUPPLY THE TOWN OF STONEHAM WITH WATER.

Be it enacted, etc., as follows:

Town of
Stoneham may
be admitted
into the

SECTION 1. The metropolitan water board shall on application admit the town of Stoneham into the metropolitan water district, and furnish water to the same on the terms prescribed

by chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five for the cities and towns included in said metropolitan water district, and on such payment of money as said board may determine; and said town of Stoneham may supply itself and its inhabitants with water for the extinguishment of fires and for domestic and other purposes, obtaining the same from said board, by applying to be admitted into said district; and may establish fountains and hydrants, relocate or discontinue the same, may regulate the use of such water and fix and collect rates to be paid for the use of the same.

SECTION 2. Said town, for the purposes aforesaid, may hold and convey the water to be furnished by said metropolitan water board as hereinbefore provided, through said town, and may also take and hold, by purchase or otherwise, all lands, rights of way and easements necessary for holding, storing, purifying and preserving such water and for conveying the same to any part of said town of Stoneham; and may erect on the lands thus taken or held proper dams, reservoirs, buildings, fixtures or other structures; and may make excavations, procure and operate machinery, and provide such other means and appliances as may be necessary for the establishment and maintenance of complete and effective water works; and may construct and lay down conduits, pipes and other works, under and over any lands, water courses, railroads or public or private ways, and along any such way, in such manner as not unnecessarily to obstruct the same; and for the purpose of constructing, maintaining and repairing such conduits, pipes or other works, and for all proper purposes of this act, said town may dig up any such lands, and may enter upon and dig up any such ways in such manner as to cause the least hindrance to public travel thereon. The title to all lands taken or purchased under the provisions of this act shall vest in said town, and the land so taken may be managed, improved and controlled by the board of water commissioners hereinafter provided for, in such manner as they shall deem for the best interests of said town.

SECTION 3. Said town shall, within ninety days after the taking of any lands, rights of way or easements as aforesaid, otherwise than by purchase, file and cause to be recorded in the registry of deeds for the southern district of the county of

metropolitan
water district,
etc.

May take
certain lands,
rights of way,
etc.

May erect
structures, lay
down pipes, etc.

Title to lands to
vest in town,
etc.

Description of
lands, etc., to
be recorded.

Middlesex a description thereof sufficiently accurate for identification, with a statement of the purpose for which the same were taken, signed by the water commissioners hereinafter provided for.

Damages.

SECTION 4. Said town shall pay all damages sustained by any person or corporation in property by the taking of any lands, rights of way or easements, or by any other thing done by said town under the authority of this act. Any person or corporation sustaining damages as aforesaid under this act, who fails to agree with said town as to the amount of damages sustained, may have the damages assessed and determined in the manner provided by law when land is taken for the laying out of highways, on making application at any time within the period of one year from the taking of such land or other property or the doing of other injury under the authority of this act; but no such application shall be made after the expiration of said one year.

Town may
tender a
specified sum
as damages, etc.

SECTION 5. In every case of a petition to the superior court for an assessment of damages the town may tender to the complainant or his attorney any sum, or may bring the same into court to be paid to the complainant, for the damages by him sustained or claimed in his petition, or may in writing offer to be defaulted and that damages may be awarded against it for the sum therein expressed; and if the complainant does not accept such sum, with his costs up to that time, but proceeds in his suit, and does not recover greater damages than were so offered or tendered, not including interest on the sum recovered in damages from the date of such offer or tender, the town shall have judgment for its costs after said date, for which execution shall issue; and the complainant if he recovers damages shall be allowed his costs only to the date of such offer or tender.

Town of
Stoneham
Water Loan.

SECTION 6. Said town may, for the purpose of paying the necessary expenses and liabilities incurred under the provisions of this act, issue from time to time bonds, notes or scrip to an amount sufficient for such purpose, to be determined by the board of water commissioners hereinafter provided for. Such bonds, notes or scrip shall bear on their face the words, Town of Stoneham Water Loan, shall be payable at the expiration of periods not exceeding thirty years from the date of issue, and shall bear interest payable semi-annually at a rate not exceed-

ing four per cent. per annum, and shall be signed by the treasurer of the town and countersigned by the water commissioners hereinafter provided for. Said town may sell such securities at public or private sale, or pledge the same for money borrowed for the purposes of this act, and upon such terms and conditions as it may deem proper: *provided*, that such securities shall not be sold for less than the par value thereof. Said town shall provide at the time of contracting said loan for the establishment of a sinking fund, and shall annually contribute to such fund a sum sufficient with the accumulations thereof to pay the principal of said loan at maturity. Said sinking fund shall remain inviolate and pledged to the payment of said loan and shall be used for no other purpose.

Sinking fund.

SECTION 7. Said town instead of establishing a sinking fund may at the time of authorizing said loan provide for the payment thereof in such annual proportionate payments as will extinguish the same within the time prescribed in this act; and when such vote has been passed the amount required thereby shall without further vote be assessed by the assessors of said town in each year thereafter until the debt incurred by said loan shall be extinguished, in the same manner as other taxes are assessed under the provisions of section thirty-four of chapter eleven of the Public Statutes.

May provide for annual payments on loan.

SECTION 8. Said town shall raise annually by taxation a sum which with the income derived from water rates will be sufficient to pay the current annual expenses of operating its water works, including therein any annual payment to said metropolitan water board, and the interest as it accrues on the notes, bonds and scrip issued as aforesaid by said town, and such contributions to the sinking fund and payments on the principal as may be required under the provisions of this act.

Payment of expenses, etc.

SECTION 9. Whoever uses any water taken under this act without the consent of said town, or wilfully or wantonly corrupts, pollutes or diverts any of the waters taken or held by said town pursuant to the provisions of this act, or destroys or injures any structure, work or other property owned, held or used by said town under the authority and for the purposes of this act, shall forfeit and pay to said town three times the amount of damages assessed therefor, to be recovered in an action of tort; and upon conviction of either of the above wilful or wanton acts shall be punished by a fine not exceeding

Penalty for corruption of water, etc.

three hundred dollars or by imprisonment not exceeding one year.

Liability for
payment of rent
for use of
water.

SECTION 10. The occupant of any tenement shall be liable for the payment of the rent for the use of water in such tenement, and the owner shall also be liable in case of non-payment by the occupant for all sums due for the use of water under this act, to be collected in an action of contract in the name of the town of Stoneham.

Water
commissioners,
election,
terms, etc.

SECTION 11. Said town shall after the acceptance of this act, at a legal meeting called for the purpose elect by ballot three persons to hold office, one until the expiration of three years, one until the expiration of two years and one until the expiration of one year from the next succeeding annual town meeting, to constitute a board of water commissioners: and at each annual town meeting thereafter one such commissioner shall be elected by ballot for the term of three years. No person shall be elected commissioner who holds at the time any town office by popular election. All the authority granted to the town by this act and not otherwise specially provided for shall be vested in said board of water commissioners, who shall be subject however to such instructions, rules and regulations as said town may impose by its vote. The said commissioners shall be trustees of the sinking fund herein provided for and a majority of said commissioners shall constitute a quorum for the transaction of business relative both to the water works and to the sinking fund. Any vacancy occurring in said board from any cause may be filled for the unexpired term by said town at any legal meeting held for the purpose.

To be trustees
of sinking
fund, etc.

Vacancy.

To fix prices
for use of
water, etc.

SECTION 12. Said commissioners shall fix such prices or rents for the use of water as shall produce annually as near as may be a net surplus over operating expenses, including therein any annual payment to said metropolitan water board, and interest charges equal to two per cent. of the total amount of the bonds, notes or scrip issued under this act, after paying all current expenses of operating the water works and interest upon loans, and after payment of all expenses for new construction not exceeding one thousand dollars in any one year after the original construction. The sinking fund shall be set apart for the payment and redemption of said water loan, and shall remain inviolate and pledged to the payment of said loan and shall be used for no other purpose. The net surplus afore-

said shall be paid into the sinking fund if any is established hereunder, and if said surplus does not equal two per cent. of the total amount of the bonds, notes and scrip issued under this act the town shall raise by general taxation a sum which with the surplus will equal said two per cent. and shall contribute said sum to the sinking fund. Said commissioners shall annually, and as often as the town may require, render an account of all their doings in relation to the sinking fund, and shall be governed by the provisions of section eleven of chapter twenty-nine of the Public Statutes, except as herein otherwise provided.

To render an account of their doings, etc.

SECTION 13. If within thirty days after this act shall have been accepted by the town of Stoneham, as hereinafter provided, the Wakefield Water Company shall notify the chairman of the board of selectmen of said town in writing that it desires to sell to said town such portion of its mains, pipes, hydrants, gates and fixtures as are situated within the territorial limits of the town of Stoneham and are now used for the purpose of supplying said town and its inhabitants with water, excepting however its standpipe and all main pipes through which water is supplied to said standpipe or to the town of Wakefield or its inhabitants, reserving the right to use the property which it desires to sell, as aforesaid, for supplying said town of Stoneham and the inhabitants thereof with water, at rates not exceeding those charged therefor at the time of the passage of this act, for a period not exceeding two years, terminating whenever said town of Stoneham, having voted to purchase as hereinafter provided, shall notify said company in writing that thereafter it desires the exclusive use of said property, said company agreeing to continue to use said property for so supplying water, and to keep the same in good repair for such period, and further agreeing that at the end of said period it shall cease to have any right to supply said town of Stoneham or its inhabitants with water in any manner, and shall file with the town clerk of said town a specification and description of said property, said town shall not proceed to construct a distributing system for the water to be supplied to it and its inhabitants, under the authority of this act, unless it shall have first purchased of said company the property aforesaid; and said company is authorized to make sale of said property to said town, and said town is authorized to purchase the same and manage and use the

Town of Stoneham may purchase certain property of Wakefield Water Company.

Commissioners
to be appointed
to determine
value of
property in case
of failure to
agree, etc.

property thus conveyed for the purposes and under the provisions of this act. Whenever, within one year from the passage of this act, said town shall by a majority vote of the legal voters of said town present and voting thereon at a legal meeting called for that purpose, or at any annual town meeting, vote to purchase said property, notice of the desire of said company to sell the same having been given as hereinbefore provided, said property shall thereupon become the property of said town, and said town shall pay to said company the fair value thereof, to be ascertained as hereinafter provided. In case said town and said company, after conference thereon, shall be unable to agree upon the value of said property, the supreme judicial court shall, upon application by either party and notice to the other, appoint three commissioners, one of whom shall be learned in the law and one a skilled engineer, who shall determine the fair value of said property, without allowance for past, present or future earnings or earning capacity, good will or any franchise or privilege of said company, and whose award, when accepted by the court, shall be final; but said company shall not be entitled to receive any payment as hereinbefore provided so long as any lien or other incumbrance remains upon said property or any part thereof, unless said commissioners shall otherwise determine, and said award shall not be paid until the time when said company shall finally cease to supply water to said town of Stoneham and its inhabitants, as hereinbefore provided, and it shall draw interest only from that time.

To be sub-
mitted to voters
at a legal town
meeting, etc.

SECTION 14. This act, except as provided in section fifteen, shall take effect upon its acceptance by a majority vote of the voters of the town of Stoneham present and voting thereon at a legal town meeting called for the purpose within one year from its passage; but the number of meetings so called shall not exceed three.

When to take
effect.

SECTION 15. So much of this act as authorizes the submission of the question of its acceptance to the legal voters of said town shall take effect upon its passage, but it shall not take further effect unless and until accepted as hereinbefore provided by the qualified voters of said town. [*Approved June 7, 1897.*]

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